FREE
2004 SKY EVENTS GUIDE

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Orion's kid-friendly StarBlast scope PAGE 84

How dreams of space flight became real PAGE 48

January 2004
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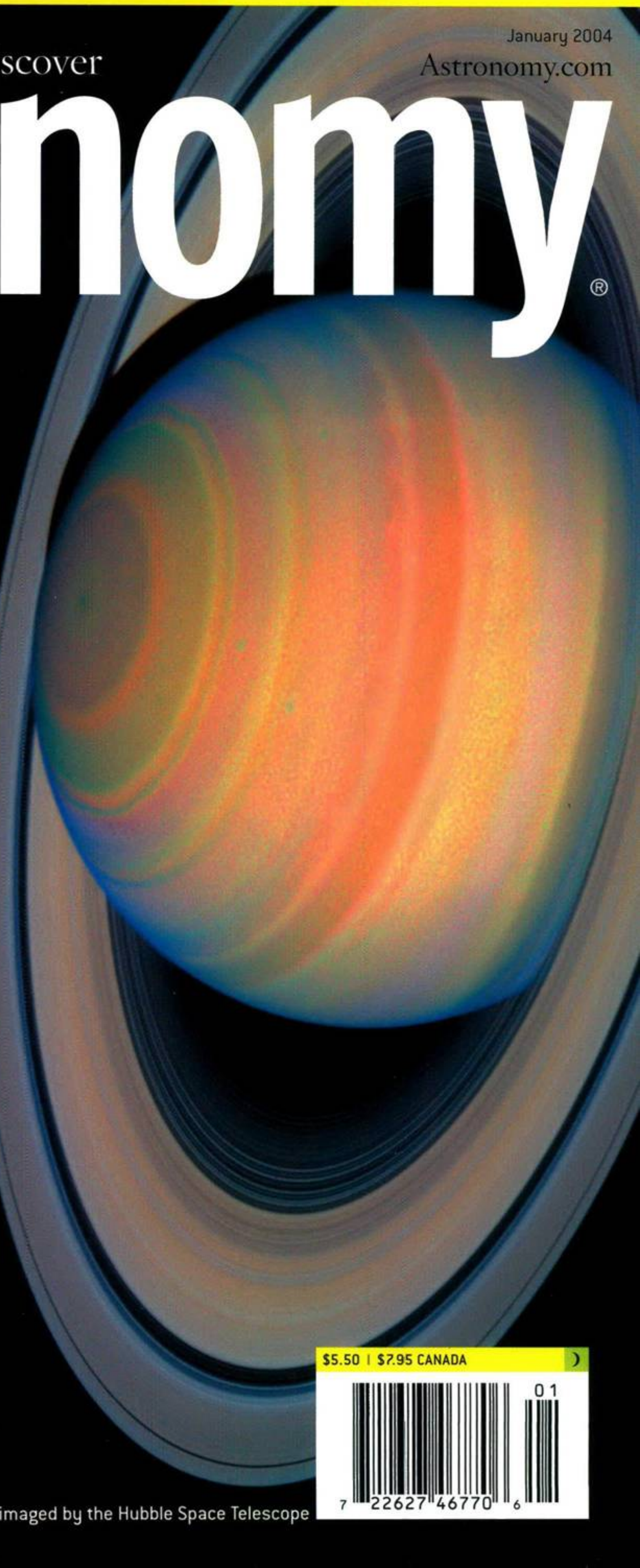

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Bob Berman's strangest astronomy questions

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- Includes cables to connect your Autostar-equipped telescope to your PC.

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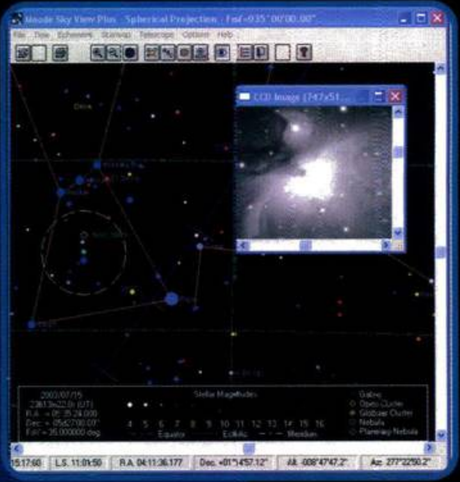
**For use with other Meade telescopes see the Meade web site.



Planetarium program showing Orion region.

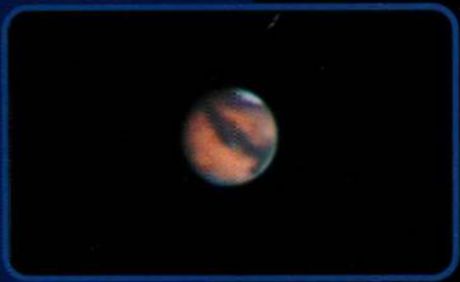


Image of Mars made with an LPI connected to a 12" LX200GPS, a composite of 36 images automatically selected and registered by the Autostar Suite software. Control of the telescope was via Autostar Suite remotely over a network connection.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

***Visit the Meade web site at www.meade.com for complete description of features and detailed specifications.**

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70 • 90 • 105 • 125 ETX MEADE AUTOSTAR

The telescopes that have revolutionized amateur astronomy are now available with Autostar® and Field Tripod at very special low prices!

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Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope	**$595**
ETX-105AT Astro Telescope	**795**
ETX-125AT Astro Telescope	**995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

ETX-70AT Astro Telescope	**299**

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

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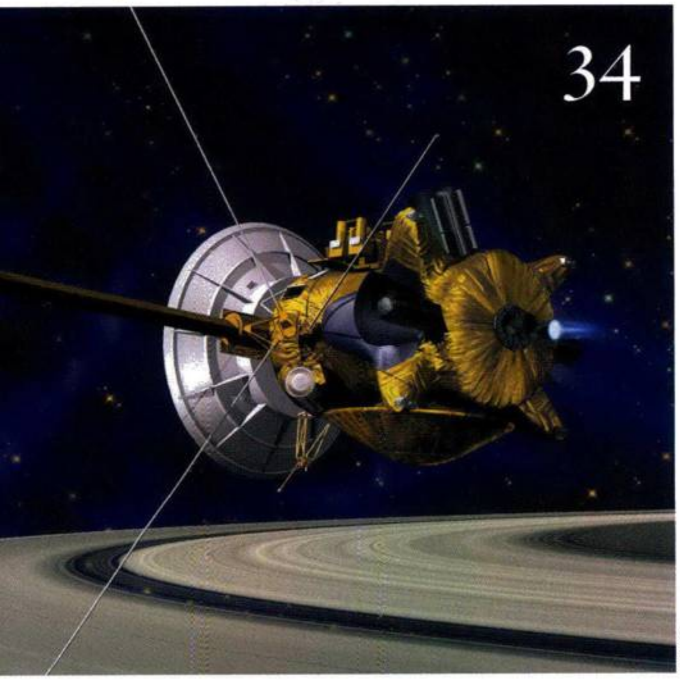
january 04

features



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COVER STORY

34 Journey to Saturn

If all goes according to plan, the Cassini spacecraft will run rings around the Voyager flybys of Saturn. And that's not even counting the Huygens probe, which will parachute to the surface of the enigmatic moon Titan.

ALFRED S. MCEWEN

EXTRAGALACTIC ASTRONOMY

42 In the line of fire

Since their discovery in the '70s, gamma-ray bursts have stumped astronomers. Now, research suggests these energetic blasts originate in the violent deaths of massive stars. STEVE NADIS

SPACE EXPLORATION

48 "Space flight is utter bilge."

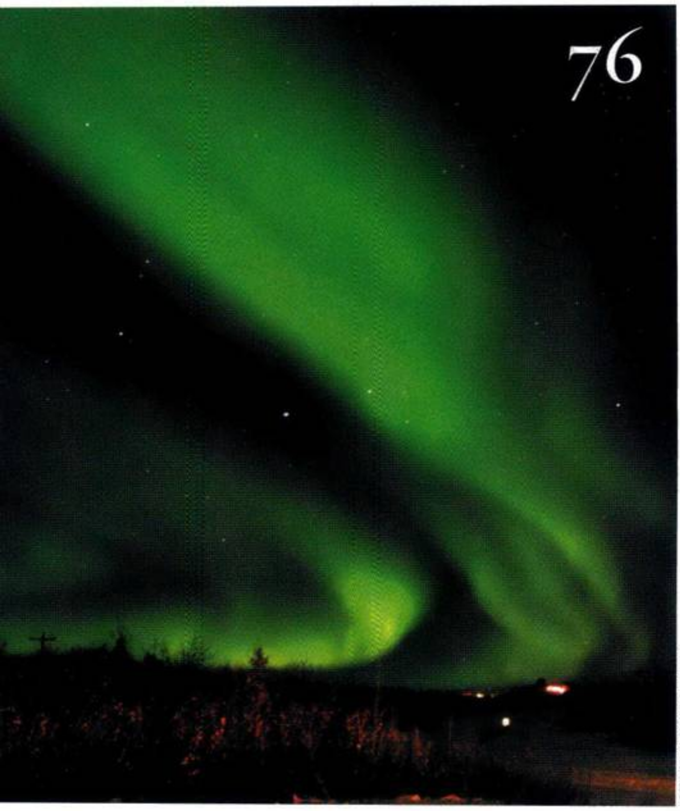
Despite skepticism and ridicule from scientists and the public alike, a small handful of dreamers kept faith in their vision of space flight and planned for the day when humanity would break loose from Earth. DONALD YEOMANS

TRAVEL

76 From heaven on Earth . . . into thin air

Last year, *Astronomy*'s tours to Alaska and Hawaii featured spectacular views of everything from the northern lights to the Southern Cross. This year's excursions promise to be just as eventful.

RICHARD TALCOTT AND DAVID J. EICHER



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ASTRONOMY: RICHARD TALCOTT

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82 Lunar Apennines

You'll be scrambling to set up your scope after you read this fascinating story of crater formation and destruction in this rugged area of the Moon.

ROBERT BURNHAM

PRODUCT REVIEW

84 Orion's StarBlast

Orion's new telescope for kids offers a wide field of view, good images, portability, and low cost — and the best thing is you don't have to be a kid to enjoy it. PHIL HARRINGTON

PLANETARY OBSERVING

88 Saturn in prime time

Take advantage of this year's favorable appearance of Saturn. A longtime watcher of the Ringed Planet shares his helpful tips and techniques to enhance your observing. JULIUS L. BENTON, JR.

FABRIZIO MELANDRI

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CASSINI MISSION: The spacecraft's instruments will use many strategies to study Saturn.

GAMMA-RAY BURSTS: How do different types of cosmic flashes relate to each other?

SPACE-FLIGHT DREAMS: Explore yesteryear's plans for humankind's great future in space.

ALASKA AND HAWAII: View more pictures, and read about an amateur's night at the Keck Observatory.

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SATURN EXPOSED
Your best view of Saturn — NOW!

ON THE COVER

Saturn puts on its best show of 2003 on December 31, when it will shine at magnitude –0.3 and present its dazzling rings and array of moons to telescopic observers. At the same time, the Cassini-Huygens spacecraft will be speeding toward the giant planet, heading for a summer 2004 arrival. STScI

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BY DAVID J. EICHER

Cassini's long cruise to Saturn

Perhaps the most exciting times in astronomy over the past thirty years have come when major spacecraft reached their destinations: the Viking landers setting down on Mars, providing panoramic images of the Red Planet; the Voyagers cascading through the systems of Jupiter and Saturn, giving us our first good look at these gas giants. More recently, Mars Pathfinder and Galileo re-examined what we thought were familiar worlds in greater detail.

We are about to begin a new chapter in the story of planetary exploration. After seven years of interplanetary voyaging, NASA's Cassini-Huygens spacecraft, a multinational effort, will arrive at the Ringed Planet this coming July. Cassini-Huygens will commence the most thorough scientific look at a planet ever undertaken, exploring the jewel of the solar system and its 31 moons. The mission's milestones will be numerous; before arriving in orbit, the spacecraft will swing past Saturn's moon Phoebe on June 11. The craft will then enter the ring plane in early July. Enormous quantities of data, including stunning imagery, will no doubt be transmitted home over the following weeks and months. And on December 24, 2004, Cassini will drop the Huygens probe, named for the celebrated Dutch astronomer, which will coast downward into the murky atmosphere of Saturn's largest moon, Titan, and land on the moon's icy surface.

Cassini-Huygens will be one of the most exciting missions in the history of solar system astronomy. *Astronomy* commences our coverage of this spectacular event with Alfred S. McEwen's mission overview, "Journey to Saturn," on page 34. McEwen is a planetary scientist at the University of Arizona and a member of Cassini's imaging team. His expert, behind-the-scenes look at Cassini kicks off a series of stories about the mission that will appear in our pages throughout the year.

For a major contrast, see "In the line of fire" by contributing editor Steve Nadis (page 42), which describes current research on the mysterious blasts known as gamma-ray bursts. This rapidly evolving field has taken some weird twists down the interpretive road that will leave you amazed. Along another vein entirely, " 'Space travel is utter bilge' " by Donald Yeomans (page 48) delivers a crisp view of this bygone era from the earliest thoughts of space travel to the Cold War superpower rivalry that marked the space age.

On another note, *Astronomy's* contributing editor Ray Jayawardhana has won the 2003 American Institute of Physics Science Writing Award for his story "Beyond black" in the June 2002 *Astronomy*. Ray is an assistant professor of astronomy at the University of Michigan in Ann Arbor. His article explored whether astronomers really know black holes exist. Congratulations, Ray!

As always, I invite you to contact me with comments about the magazine. E-mail me at editor@astronomy.com.

Yours truly,

Dave Eicher
Editor

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VoL. 32 No. 1

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The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
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With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695. Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide. Prices effective 10/1/03.

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LXD55

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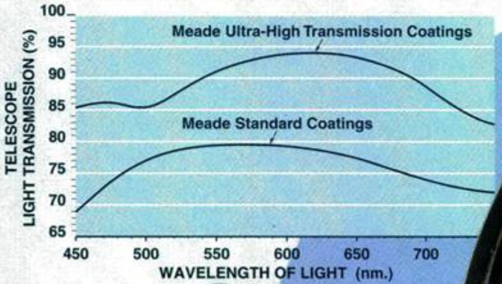
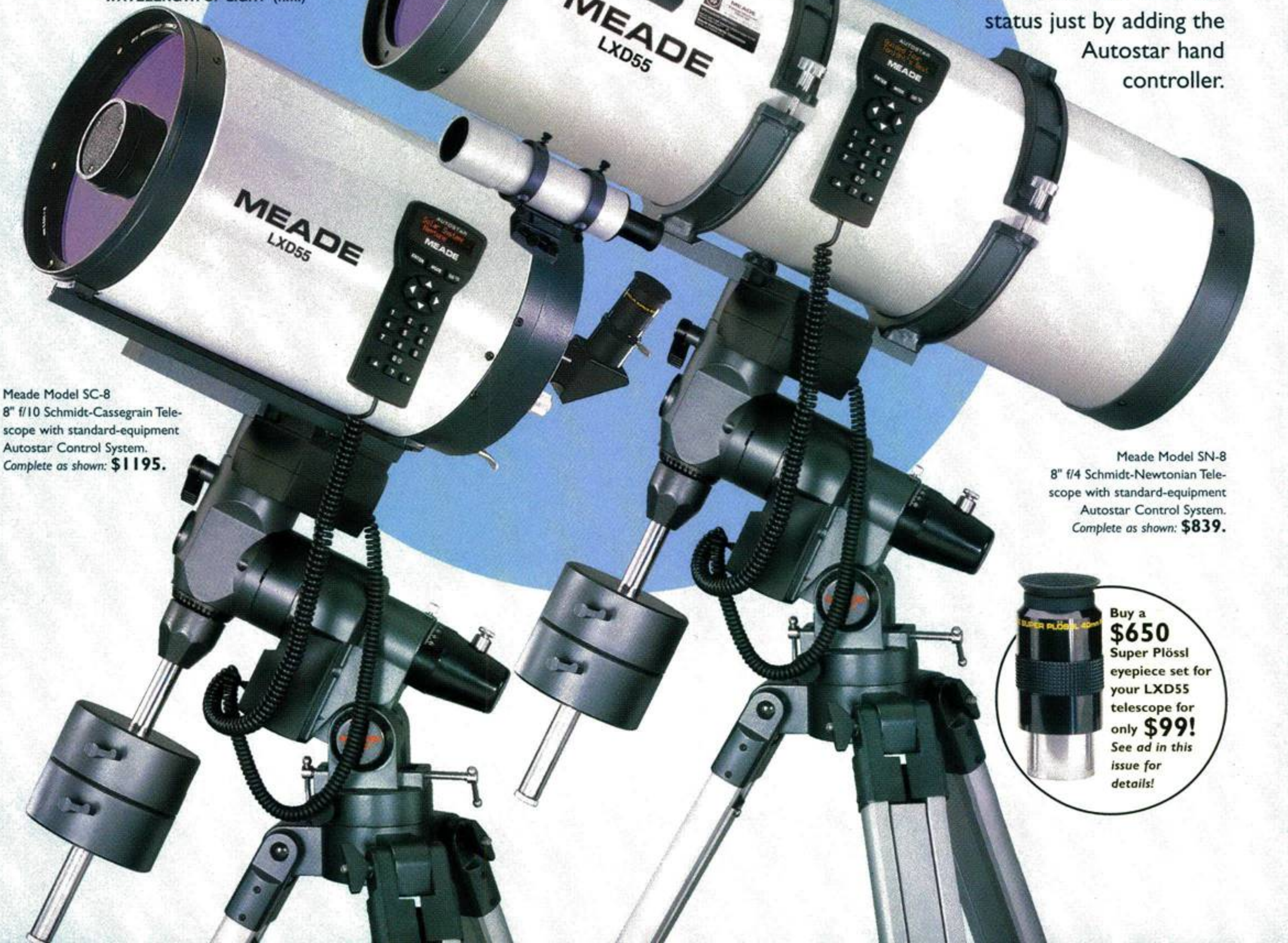


Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.



Meade Model SC-8
8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
Complete as shown: **$1195.**

Meade Model SN-8
8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.
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6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

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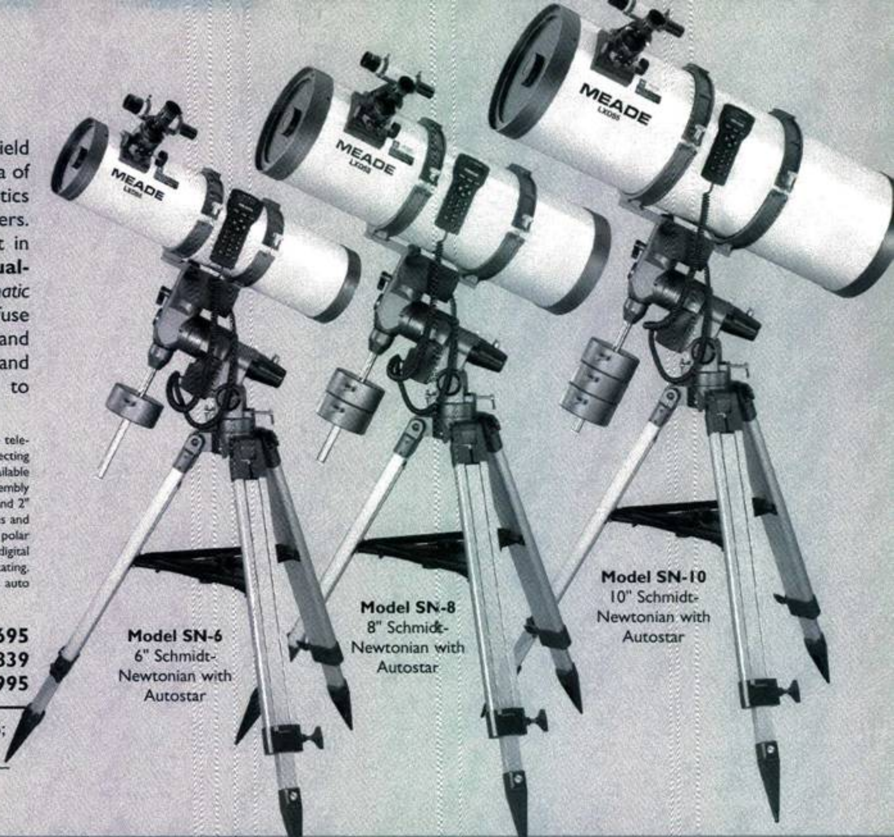
SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

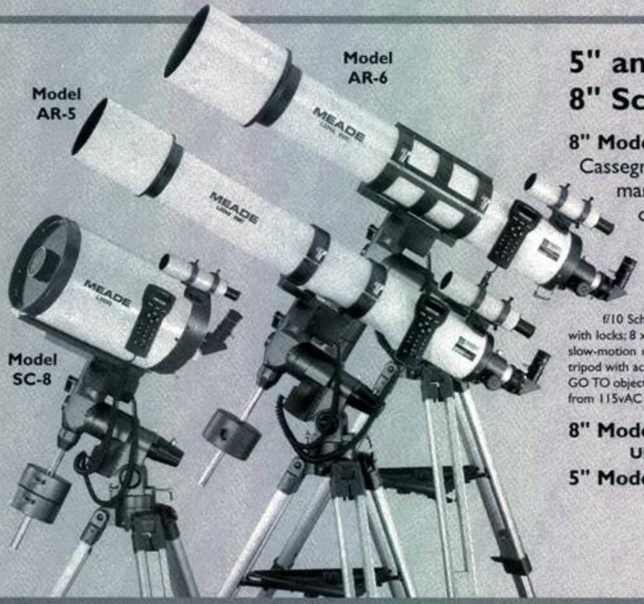
Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.



Model SN-6
6" Schmidt-Newtonian with Autostar

Model SN-8
8" Schmidt-Newtonian with Autostar

Model SN-10
10" Schmidt-Newtonian with Autostar



5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

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8" Model SC-8 Schmidt-Cassegrain	**$1195**
UHTC group for Model SC-8 — $175	
5" Model AR-5 Achromatic Refractor	**695**
6" Model AR-6 Achromatic Refractor	**895**

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; 4.5°/second for rapid-slew of the telescope across the sky; plus automatic sidereal-rate RA tracking. ***#497 Autostar Controller may be added at any time in the future and permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2003

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Model SN-6EC
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Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller

Model AR-5EC
5" Achromatic Refractor with Electronic Controller

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Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal. **Super Plössls** (SP; 4-elements; 1.25"; 52°): **6.4, 9.7, 12.4, 15, 20, 26mm** each: **$79.95** (4.54); **32mm** (52°); **40mm** (44°) each: **99.95** (5.26); **56mm** (52°; 2") **199.95** (7.02)

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries. **$249.95** (9.85)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

CCD-Photo-Visual Flip-Mirror Systems

Use with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

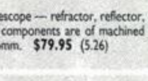
Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

2x Short-Focus Barlow (1.25")



#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

New! 2" Diagonal Mirrors with UHTC

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders. **#929** or **#930,** each: **$119.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.86)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models: **99.95** (8.58)
#776 Case for ETX-105 models: **99.95** (8.58)
#775 for ETX-125 models: **149.95** (13.38)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models: **$119.95** (6.85)

#1247 Electric Focuser for ETX-125 models: **$119.95** (6.85)

World's Most Advanced Illuminated Reticle Eyepiece

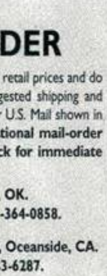
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

MA12mm Illuminated Reticle Astrometric Eyepiece

A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photoguiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece



The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

Dew Shields for ETX®

Threads into the front lens-cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70 . . . . **19.95**
#673 for ETX-90. . . . . . . **24.95**
#675 for ETX-105. . . . . . **27.95**
#678 for ETX-125. . . . . . **29.95**

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

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Orders: 800-422-7876; Info.: 405-364-0858.

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Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
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RIVERS CAMERA, Dover, NH.
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FOCUS CAMERA, Brooklyn, NY.
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The Meade 30th anniversary sale

Buy a Meade telescope and receive a $650 Meade Super Plössl eyepiece set for only $99!

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SUPER PLÖSSL 9.7mm
PLÖSSL 12.4mm
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PLÖSSL 20mm
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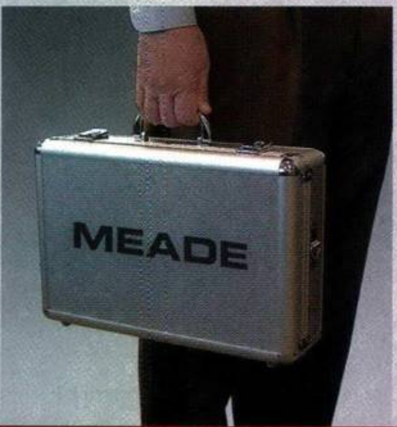
SUPER PLÖSSL 32mm
SUPER PLÖSSL 40mm

Now for a limited time, to celebrate Meade Instruments' 30 years in telescopes, you can buy a Meade telescope* and receive a full set of Meade premium-grade Super Plössl eyepieces for only $99 additional. Never before have we made such an incredible offer available for such a wide range of our most popular telescope models.

Choose from more than a dozen qualifying Meade telescopes *(see listing at right)*, mail us your check for $99, and we'll ship your Super Plössl eyepiece set directly to you. And we'll pack your eyepieces in the Meade #771 foam-lined aluminum carrying case, itself a $49.95 value if purchased separately. For complete details see the HOW TO ORDER box at right.

Designed and manufactured to exacting standards, Meade Series 4000 Super Plössl eyepieces deliver wide 52° apparent fields (44° for the SP40mm) with all of the resolution, edge-of-field sharpness, and color correction demanded in the most advanced visual applications. All eyepieces are brand-new and factory fresh; each is multicoated, includes a soft rubber eyeguard, and is individually packed in a thread-on poly container. There are no finer general-purpose eyepieces available.



The Meade #771 aluminum carrying case, included with this special offer, provides rugged, secure storage for your Super Plössl eyepiece set.

This special offer includes the following eyepieces:

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SP15mm	79.95
SP20mm	79.95
SP26mm	(standard equipment)**
SP32mm	99.95
SP40mm	99.95
#771 Aluminum Carrying Case	49.95
Total price if purchased separately:	**$649.60**

***Telescopes qualifying for this special offer include:**

ETX (EC or AT) models: ETX-90, ETX-105, ETX-125
LXD55 models: 6" SN-6, 8" SN-8, 10" SN-10, 8" SC-8, 5" AR-5, 6" AR-6, 6" SN-6EC, 8" SN-8EC, 5" AR-5EC
LX90, LX200GPS models: 8" LX90; 7", 8", 10", 12", 14", 16" LX200GPS

HOW TO ORDER

1. Buy any qualifying Meade telescope from an authorized Meade dealer in the U.S.A.

2. Fax or mail a copy of your dealer's invoice, plus the completed warranty card packed with the telescope, along with your payment of $99 to Meade Instruments/Attn: Customer Service, and request the "$99 Eyepiece Offer." *Requests must include your complete shipping address and phone number.*

3. We will ship your eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed.

Other terms and conditions: Payment may be made by personal check (payable to Meade Instruments) or credit card (VISA or MasterCard). **California residents must add $7.67 sales tax, for a total payment of $106.67.** This special offer is valid only for new Meade telescopes ordered and received within the U.S.A. after 8/15/02 and is subject to change without notice. (Outside the U.S.A. contact your Meade international distributor.) There is no limit to the quantity of telescopes each person may order: each qualifying telescope is eligible to receive the special eyepiece package. Prices shown are suggested U.S. mail-order retail prices. **The SP26mm eyepiece (shown in photos above) is packed with each qualifying telescope as standard equipment.

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Extreme astronomy

On the morning of August 27, 2003, the collective telescopes of Earth turned toward Mars as the two planets came closer than they had in more than 60,000 years. People everywhere clamored for a look through a telescope, any telescope, but we had a loftier goal: We rented the 100-inch Hooker telescope high atop Mt. Wilson, California.

We had two worries that could nix the plan. First, dust storms on Mars, common when the planet is this close to perihelion, could obscure the view. Second, the incredibly high magnification of the system would require very steady seeing. Given a 100-inch aperture and a focal ratio of 30, the focal length was an incredible 3,000 inches (76,200mm). The eyepiece was a 2" Plössl, so the system yielded a magnification of 1,361x. To make matters worse, Mars would be relatively low in the sky from Mt. Wilson, so we'd be looking through a lot of Earth's atmosphere.

The day before the opposition, things did not bode well: Thunderstorms battered southern California. But by evening, the storms had cleared and the stars came out steady, with no visible twinkle.

It was one of those nights Mt. Wilson is famous for. The chronic inversion layer that holds in the smog over Los Angeles creates a smooth ramp to the mountaintop for marine air from the Pacific. While the seeing wasn't perfect, Mars frequently popped into sharp, almost three dimensional, view. When the seeing was steady, surface features looked like photographs.

At our location, the closest approach occurred at 1:20 A.M. local time, when the two planets were just 34,643,890 miles apart. In order to decide who would be at the eyepiece at that instant, we drew straws: Tara Brooks of Burbank, California, was the winner. She was at the eyepiece of one of the largest telescopes in the world looking at Mars when it came closest to our point on Earth!

ALL EYES WERE ON MARS during its opposition this past August, but the view from space was unparalleled: Hubble snapped this image eleven hours before the Red Planet's closest approach. NASA, J. BELL (CORNELL UNIV.), AND M. WOLFF (SSI)

ROY MAYHUGH, MAYHUGH TRAVEL
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Academic exchange

In response to the article about David Helfand ("The outsider," October 2003), I would like to make two simple points. First, I have no recollection of any public exchange between Dr. Helfand and myself on the subject. Second, the validity of the Einstein results regarding the contribution of discrete sources to the X-ray background has been confirmed and extended by observations with the ROSAT and Chandra missions. It is now generally agreed that more than 90 percent of the X-ray background is due to discrete objects.

DR. RICCARDO GIACCONI
ASSOCIATED UNIVERSITIES, INC.

Regarding Dr. Giacconi's letter, he is correct that recent, sensitive observations with Chandra have shown convincingly that the X-ray background arises in discrete objects.

That issue is not in dispute now, nor was it in 1989. The debate was over whether or not objects fainter than the limits of the Einstein observations could be extrapolated to lower fluxes directly, or whether there was a break in the extrapolation indicating a new population of discrete sources was contributing to the X-ray background.

My contention that a break was required also has been confirmed by the recent, more sensitive observations. The spurious sources published in Dr. Giacconi's first analysis of the Einstein Observatory Deep Surveys that were pointed out in my and my colleagues' 1991 paper (*Astrophysical Journal*, 379: 576) do not appear in his revised analysis, also published in *Astrophysical Journal* in 1991. So I conclude there is no longer a dispute concerning this matter either.

As for the meeting in question, it occurred in July 1989 in Tsiblisi, (Soviet) Georgia. Dr. Giacconi's assertion of my mendacity can, I suspect, be recalled by several of the astronomers in attendance. In fact, I do not consider heated exchanges in scientific debates the least disturbing, and I did not take particular umbrage at the time, nor do I now. The arbiter of such disputes is always nature, examined with the clever instruments — in this case, Dr. Giacconi's own magnificent Chandra Observatory — that we devise.

PROF. DAVID HELFAND
COLUMBIA UNIVERSITY

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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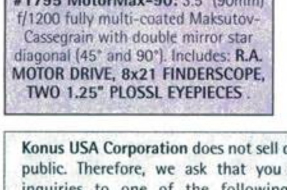

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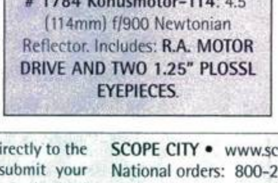

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BY BOB BERMAN

Stupidity smarts

September's "Strange universe" (" 'F' in Science") invited readers to send in the dumbest astronomy questions they've ever heard. ☾ We've been flooded. So many terrific responses made it impossible to choose just one winner, but we did manage to select the "top five." ☾ One reader enthusiastically requested an " 'F' in Science, Part Two," while others criticized the article, feeling that nobody's astronomical query, no matter how silly, should be ridiculed. Good point. All of us are students of astronomy, and in truth, inquiry should always be respected. The tongue-in-cheek idea of a "contest" was to spotlight the woeful inadequacy of the public's astronomy awareness. We could editorialize about how the education system must do better, but hearing actual questions from real people makes the point with greater impact — and with a little fun.

There is certainly no shame in being unable to identify a single star. Yet, it's astonishing that so many people do not know the stars are farther away from Earth than the Moon. It is that extreme degree of astronomy-disability we are addressing here. We can allow ourselves to chuckle at wild misconceptions if it also inspires those of us who treasure the heavens to "spread the word" — to share its glories with anyone curious to learn.

> { . . . nor the time I searched in vain for a galaxy, with students getting more impatient by the minute, before realizing the dust cap was still on."

My thanks to all the respondents — from around the world — for their positive energy and kind comments. The winning "top five" were chosen from among the finalists listed below.

The finalists were: Jon Blair Thompson; Keith Rivich; Mario Kienspergher; Nick Mahalko; Richard Hartman; John Landreth; Terrence Jacobs; Helga Szmuk; Paul Persijn; Mike Martin; Andrew Carson; Kelly Timpson; Ed Dombrowski; Mark Kardos; Erick Swearingin; Alan Lipkin; and Curt Renz.

And the winners are . . .

Honorable mention:

"If you could see X rays, what color would they be?"

5. "During Europe's 1999 solar eclipse, I explained to a group of people the location of various planets in the sky during totality. One person asked, **'And during the eclipse, where will the Moon be?'** "

(Of course, when you view any eclipse, solar or lunar, you're automatically looking at the Moon.)

4. "A high school senior asked me, her science teacher: **'If the Sun is a star, why can't we see it at night?'** "

3. Another science teacher sent in a photocopy of the original note from a high school student (maybe thinking that unless he supplied proof, we wouldn't believe it). This senior, after looking at a photograph of Earth from space, asked, **"What keeps the blue from falling off?"**

2. "A man asked, **'If stars are so huge, how did the astronauts steer around them on their way to the Moon?'** "

1. "After hearing a radio announcer warn listeners not to stare at the upcoming solar eclipse, one woman called the station and asked in an exasperated tone, **'If the eclipse is so dangerous, why are they having it?'** "

Now, it's only fair that I present my dumbest astronomy moment. No, not the day the Sun struck my eye full force while I was sweeping my scope across the sky looking for Venus; nor the time I searched in vain for a galaxy, with students growing more impatient by the minute, before realizing the dust cap was still on.

Years ago, I wrote an article for a major magazine about upcoming eclipses and where they would be visible. Consulting a popular reference source, I listed the track of totality for the 1998 eclipse as including St. Kitts, an island in the Caribbean. After that eclipse, the magazine received two letters from readers who had traveled to St. Kitts, only to find that totality missed the island and swept across adjacent ones.

I felt awful. And stupid. I phoned my source to complain and also asked the magazine's editor how that boo-boo had eluded the fact-checkers. But those were cop-outs; the fault was entirely my own — by being too lazy to cross-check the data against other references.

I still turn red when I think of that. And I wince when recalling other, less serious errors that were just as embarrassing to me as anything in our "top five." Hubris is always dangerous, and a science that probes the universe offers significant risks when one starts feeling too smug. As they say on the dark side of the Moon, knowledge is a work in progress.

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Clear Skies!

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BY GLENN CHAPLE

'Scoping tips

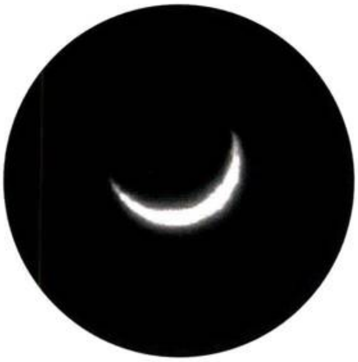
In the wake of the recent holiday season, many of you are ready to greet 2004 with a new telescope. Last month, I shared the benefits of using binoculars to observe. It only makes sense, then, to discuss the benefits of using a telescope this month. So today, I offer six pointers to help you get the most out of your new scope:

1. **Read the manual!** I know, reading a manual isn't as exciting as looking at the Andromeda Galaxy. But the manual actually contains important information about the scope's use, care, and maintenance.

2. **Attend "ground school."** Telescope "ground school" is a daytime activity where you practice aiming and focusing on distant land objects. Like astronauts, you too should go through on-the-ground training before rocketing into space — with your new telescope.

3. **Be sure your finder scope is properly aligned.** Can't find a thing with your telescope? The finder scope may be out of alignment. To fix the problem, center the finder on a distant, easy-to-recognize target (e.g., a church steeple, the top of a telephone pole). Now, look for that object in the main scope (use a low-power eyepiece). Center your target in the eyepiece's field of view, and then tighten the locking knobs on your telescope's mount so it doesn't move. Look through the finder scope and use its adjusting screws to center the target. Repeat, if necessary, until the object appears centered in both the finder scope and main scope.

4. **Start with low power.** Many neophyte telescope owners can't find anything because they start with high power. Use low power to locate and center your target, then go to higher magnifications for those close-up views. A low-power eyepiece captures a bigger chunk of sky, making it easier to sweep up an object.



THE PHASES OF VENUS closely resemble those of the Moon. Here, the crescent Venus smiles for the camera. CHRIS COOK

5. **Begin with the Moon.** Most budding astronomers are attracted naturally to the Moon. Bright and easy to locate, the Moon shows a wealth of detail. During the final days of December 2003 and the first week of January 2004, the Moon will be conveniently placed in the evening sky.

6. **Get to know the night sky.** The "all-sky" map on page 57 displays some of the major stars and constellations gracing our January sky — including Orion and its stellar neighbors, which are easily found in the southwest sky as darkness descends.

What better "first" planet for your new scope than Saturn, which arrives at opposition on December 31? As the new year begins, Saturn appears above the northeast horizon at sunset. Those fabled rings will be a joy to behold through your new scope. Best of all, you won't need high power to see them. Saturn's rings become evident in magnifications as low as 20x, and they are striking between 75x and 100x. After locating Saturn, look for a tiny "star" nearby. This is its largest moon, Titan. Watch Saturn and Titan each night for several weeks to see this moon complete an orbit of its home planet.

As exciting as Saturn is, my "planet pick" for the first half of 2004 is Venus. During January, Venus emerges from the solar glare low in the southwest sky just after sunset and becomes visible as the most brilliant evening planet. Venus will dominate the evening sky through May, outshone only by the Moon.

Perpetually veiled by a dense, cloudy atmosphere, Venus appears as a featureless, unimpressive white disk. But Venus does something the outer planets don't. As it orbits the Sun, our sister planet undergoes a series of phase changes — the same phases that startled Galileo nearly four centuries ago when he viewed Venus.

Here's a great astronomy project for the budding astronomer: Observe Venus each week using magnifications between 75x and 100x. Sketch its appearance in a notebook and record the date. By June, you'll have a comprehensive record of its phases.

In June, Venus will impress astronomers around the world. As it passes directly between Earth and the Sun, its disk will appear as a dark black spot on the Sun when viewed through the proper filter. The last Venus transit occurred in 1882.

Although it still shines as a noticeable disk, Mars has become a ghost of what it was a few months back. I hope you viewed Mars during its epic opposition last August. With a 4-inch reflector and just 100x, I clearly saw the shrinking south polar cap and was able to identify a number of surface features, including the Hellas Basin and Syrtis Major. Mars will return in the fall of 2005. While it won't quite match its record-breaking opposition of 2003, the Red Planet will still be a worthwhile target then.

NEXT MONTH: We visit the Orion Nebula. Clear skies.

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BY WILLIAM SCHOMAKER

Jay Pasachoff

From Aruba to Zambia, Williams College astronomer Jay Pasachoff has been trotting the globe since 1959 in search of fleeting pleasures of the Sun. You can bet if there's a total eclipse anywhere in the world, Pasachoff and his entourage of Willams College undergrads will be there — with a ton of observing equipment in tow.

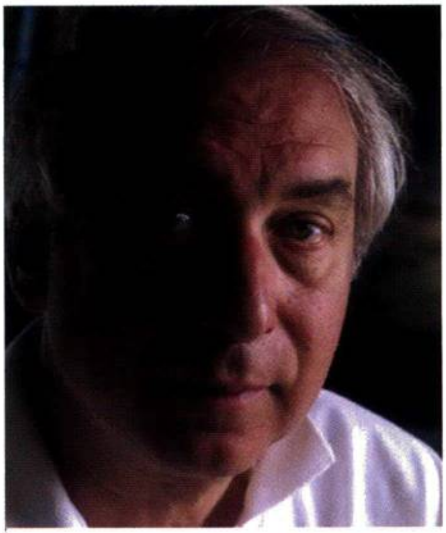
Although the Sun — especially the hot, tenuous outer layer called the corona — is Pasachoff's specialty, he has published more than twenty books covering a variety of astronomical subjects. He is also widely recognized for his contributions to the science education of middle-school students, undergraduates, and the public alike. Pasachoff is director of the Hopkins Observatory at Williams College, where he has taught astronomy since 1972. He is the recipient of the American Astronomical Society's 2003 Education Prize.

How have eclipses molded your career as an astronomer?

During my first few weeks as a freshman at Harvard, I was taken on an airplane to see a total solar eclipse. Eclipses thereafter were at the base of my thinking, although I saw only one other before I had a chance to carry out detailed observations during the 1970 eclipse in Mexico as a postdoctoral fellow. By now, I have seen 36 solar eclipses, and as Chair of the International Astronomical Union's Working Group on Eclipses, I help people around the world learn about the magnificence of total eclipses and how to safely observe them.

Describe the wonder of a total solar eclipse for those of us who've never witnessed one.

On top of the scientific thrill of studying an otherwise mostly invisible object, it is wonderful to be outdoors as the world changes all around you. The sky darkening to twilight level in the middle of the day awakens a primal feeling of wonder. The varying tint and level of light in the sky enhances the beauty of the brilliant diamond-ring effect on the Sun's edge.



JAY PASACHOFF'S 2003 Education Prize honors his myriad contributions to the cultivation of the next generation of professional astronomers. BRYAN CHARLTON

How do you prepare for the narrow observing windows offered by most eclipses?

In the thirty seconds to seven minutes of totality available during most eclipses, we try to have several independent sets of telescopes and electronic equipment ready. In December 2002, during the total eclipse in Australia, we had four scientific staff members from Williams College with us, as well as most of our undergraduate astrophysics majors, in order to set up, test, and operate the equipment — which weighed approximately one ton.

How does your ground-based work differ from what can be accomplished in space?

Some aspects of the solar corona can be observed from spacecraft, but a few niches remain in the exclusive domain of ground-based eclipse observers. The Solar and Heliospheric Observatory (SOHO) spacecraft can produce an artificial eclipse with its coronagraph. To do so, it blocks out not only the everyday solar surface but also a considerable ring around it. Our equipment can fill in that ring with images, helping to trace the corona's streamers down to their roots on the solar surface.

What other avenues of astronomy do you enjoy exploring?

In August 2002, colleagues and students from Williams and MIT joined me in using our rapid-readout eclipse camera — attached to one of the 10-meter Keck telescopes on Mauna Kea in Hawaii — to study Pluto's atmosphere as the planet passed in front of (or occulted) a star.

I'm also part of a team that collected data with the Transition Region and Coronal Explorer (TRACE) spacecraft during the most recent transits of Mercury across the Sun. From these data, we've just finished a scientific paper explaining the "black-drop effect" that baffled astronomers during the 18th- and 19th-century transits of Venus.

Meanwhile, I'm excited to observe the upcoming transit of Venus on June 8 because no such transit has occurred in the lifetime of anybody alive on Earth. ◼

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Achromatic Refractors: 5" and 6"
Schmidt-Newtonians: 6", 8", and 10"

GPS/SMT

8"

7"
8"
10"
12"
14"
16"

Meade LX90 & LX200

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8", 9.25" & 11" **GPS**

5i & 8i **GPS**

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Digital or Film— Shop Shutan for Cameras!

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Nikon D100 Digital

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TeleVue

TeleVue scopes shipped within 2 days or 10% Off!

Pronto: green or ivory with 2" diagonal, case. 20PL	$1120
TV76: green or ivory with 2" Everbrite diagonal, case. 20PL	1675
TV85: green or ivory with 2" Everbrite diagonal, case. 20PL	2080
NP101: ivory with 2" Everbrite diagonal, case	3595

We stock Vixen GP Equatorial Mounts for TeleVue refractors, inquire!

Plossl-50°	
8, 11, or 15	$82
20 or 25mm	95
32 or 40mm	110
55mm	228

Panoptic-68°	
15mm	210
19mm	240
22mm	280
24mm	295
27mm	330
35mm	365
41mm	495

Radian-60° (each)
3, 4, 5, 6, 8, 10, 12, 14, or 18 .....ea. **$240**

Nagler-82°	
3.5mm Type6	280
5mm Type6	280
7mm Type6	280
9mm Type6	280
11mm Type6	280
12mm Type4	355
13mm Type6	280
16mm Type5	320
17mm Type4	385
20mm Type5	$440
22mm Type4	460
26mm Type5	580
31mm Type5	620

Barlows	
1.25" 2x or 3x	105
1.25" 2.5x or 5x	190
2-inch 2x	198
2-inch 4x	295

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Starbeam SFT	205
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Works on ANY 1.25" telescope!
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1.25" UHC	100
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SCT Deepsky	200
SCT UHC	200

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Solar Filters!

Top-rated! Precision polished **glass.** Machined aluminum cell. Image is yellow-orange— no need for secondary filtering!

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11" full aperture	179
12" full aperture	189
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12v Controller	$75
120v adapter	65
1.25" heater	38
2" heater	40
3" heater (ETX)	43
7/8" heater	54
9"/10" heater	64
12" heater	75

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ETX90 retractable	$40
ETX105 retractable	45
ETX125 retractable	50
8" flexible	49
8" **metal**	129
10" flexible	59
10" **metal**	139
11" **metal**	169
12" **metal**	189
14" **metal**	229

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Pneumatic Viewing Stool!
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Promaster

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Mention ad for free case S/H via UPS Ground!

Use for cameras, telescope accessories and more! Carrying handle, wide shoulder strap, metal reinforced corners, keyed latches and metal hinges. Supplied with pluck-foam insert **AND** a set of rigid dividers so you can customize the case to fit your needs.

Three sizes: 9x15x5" **$59.95**
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8x56 Ultima	$269
9x63 Ultima	329
10x50 Ultima	229
20x80 Skymaster	299
25x100 Skymaster	349

Software

The Sky L4 PC	$249
Redshift-3 Mac	19
StarryNight Pro	149
Starry Essential	59

Telrad
$42

Meade LX
Easy-Mount

11x 20"
$105

- A must for all LX owners
- Fits 7"-14" Meade scopes
- Bumper-type registration
- 1/4" anodized alum-CNC
- Holds 11 eyepieces!
- Holds keypad securely

Celestron CGE

Easily carried by one person-- even the 14" model! Separates into easy-to-carry components. CNC machined aluminum and steel.

8", 9.25", 11", 14"

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LUMICON

LUMICON FILTERS "World's Best"

Lumicon International offers you the best and most extensive line of astronomical filters in the world. Filters for every imagined visual and astrophotographic application, in many configurations and sizes. Filters for deep-sky objects, galaxies, nebulae, planets, planetary nebulae, light-polluted skies, comets, and solar prominences. All UHC, Deep Sky, Oxygen III, and H-Beta filters are individually inspected and tested on a Perkin-Elmer Double-Beam Spectrophotometer. We proudly inscribe the % transmission for each of the primary lines. All made in the USA, and assembled in our new factory in California. All Lumicon International products come with a 100% satisfaction guarantee. Please visit our website at: www.lumicon.com for further information.

LUMICON DEEP SKY FILTER

The Lumicon Deep-Sky Filter is THE foremost broadband filter, blocking ALL mercury-vapor as well as high & low pressure sodium-vapor lamp light, neon lights and airglow, while transmitting the rest of the visible spectrum. The superior contrast gain between the object you're viewing and the black background of space allows you to enjoy viewing galaxies, nebulae, star clusters, comets, etc. from light-polluted urban skies, making it the best all-around visual light pollution filter. Ideal for visual or photographic use.

.965" – $89.95 • 1.25" – $99.95 • Brandon 1.25" – $99.95 • 2" T-Threaded – $199.95 • 48mm – $199.95 • 72mm – $399.95 • Visual Back – $199.95 • 39mm Nikon – $299.95 • 43mm Nikon – $299.95

LUMICON UHC FILTER

The original Lumicon Ultra-High-Contrast narrow bandpass filter (24nm) isolates the two doubly-ionized oxygen lines (496 and 501nm lines) and the H-beta line (486nm) emitted by planetary and most emission nebulae. The result is superb views of the Orion, Lagoon, Swan and other extended nebulae. This makes the Lumicon UHC the best all-around dark-sky nebular filter available.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON OXYGEN III FILTER

The renowned, original Lumicon OIII narrow bandpass filter (11nm) isolates just the two doubly-ionized oxygen lines (496 and 501nm lines) emitted by planetary and extremely faint nebulae. Produces near-photographic views of the Veil, Ring, Dumbbell and Orion nebula, among many other objects. You will be amazed at what the OIII filter allows you to see!

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON HYDROGEN-BETA FILTER

The Lumicon H-Beta Filter isolates only the Hydrogen-Beta line of the spectrum (486nm). Now you can view extremely faint, special objects such as the Horsehead, Cocoon and California Nebulae. In many cases, the Lumicon H-Beta Filter is the ONLY way to view these objects. A steady, transparent sky, with an 8" or larger instrument, combined with the Lumicon H-Beta Filter, all make an unbeatable combination for viewing those "notch in the belt" objects.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

LUMICON NIGHT-SKY H-ALPHA FILTER, FOR BLACK AND WHITE DEEP-SKY PHOTOGRAPHY

The Lumicon Night-Sky H-Alpha Filter is a powerful photographic aid in overcoming light pollution during deep-sky photography, and will help you achieve strikingly improved results in telephoto lens B&W astrophotography. It is ideally matched to hypersensitized 2415 film, and will reduce light pollution 10-fold, making it ideal for photography of faint emission nebulae.

Transmission for this sharp-cut-off filter is zero below 630nm, 90% at Hydrogen-Alpha 656nm, and 90-98% from 656nm to the near infrared. Both *filter* surfaces have high-efficiency anti-reflection coatings for maximum performance.

Exposures may be increased 2-10 times with the Night-Sky H-Alpha Filter, depending on the faintness of the nebula.

48mm–$69.95 • 58mm–$79.95 • 77mm–$89.95 • 82mm–$99.95

48MM COLOR FILTERS

Used in lunar and planetary observing.

Red – $29.95 • Orange – $29.95 • Yellow – $29.95 • Green – $29.95 • Blue – $29.95 • Ultra-Violet (Clear) – $29.95 • Polarizer – $49.95 • Neutral Density – $39.95

1.25" lunar & planetary photo-visuals, world's best, coming soon.

LUMICON MINUS VIOLET FILTER FOR COLOR OR BLACK AND WHITE PHOTOGRAPHY

The Lumicon Minus Violet Filter greatly improves photographs taken through lens systems, producing pinpoint star images. It is especially recommended for all telephoto lenses. This filter is made from optically flat, specially-made colored glass, and has anti-reflection coatings on both surfaces.

Recommended Films

All films can be used with the Minus Violet Filter; hypersensitized 2415 is the recommended B&W film, and is available directly from Lumicon or from any of Lumicon's authorized dealers.

Visual Use

The Minus Violet Filter can eliminate or greatly reduce the blue halo sometimes seen around stars through refracting telescopes. It is ideal for observing the moon and planets.

48mm – $49.95 • 58mm – $59.95 • 72mm – $69.95

LUMICON INFRARED BLOCKING FILTER

The Lumicon Infrared Blocking Filter completely blocks all infrared light above 750nm. Its versatile, anodized aluminum cell has 42mm male T-threads on one side and 48mm male threads with 42mm female T-threads, internal, on the other. Great for CCD camera infrared blocking purposes.

2" – $99.95

Infrared Blocking Filter 1.25" coming soon.

LUMICON UV DUST SEAL FOR MOST SCTs

The Lumicon UV Dust Seal keeps dust and insects out of your telescope. The seal mounts on the back of your SCT and accepts all attachments. It is an ultraviolet filter that passes all visible wavelengths of light with minimal absorption, no aberration, and no noticeable internal reflections. Fully Multi-Coated.

5-9.25" SCT / Mak – $39.95 • Meade 10/12/14" – $89.95 • Celestron 11/14" – $89.95

LUMICON COMET BAND FILTER

Lumicon's narrow visible bandpass (25nm) Comet Band Filter isolates the 501nm OIII and the Cyanogen lines at 511nm and 514nm. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Band Filter also helps you to better distinguish gaseous comets from dusty comets which show little contrast gain. For dusty comets, use the **Lumicon Deep Sky Filter**.

Howard Brewington, famed comet discoverer says: "I discovered Comet Aarseth-Brewington, 1989a1, using the Lumicon Comet Band Filter. The filter doubled the contrast, making the comet very easy to spot." Be the person to discover the next "Comet of the Century" using the Lumicon Comet Band Filter.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

SOLAR PROMINENCE FILTERS

The 1.5 Ang. Lumicon Solar Prominence Filter system lets you see the awe-inspiring solar prominences jutting from the edge of the sun. Sunspots and bright filaments can also be seen on the sun's surface. The filter has a 2" barrel for insertion into 2" focusers, and can be easily adapted for 1.25". It also has camera T-threads and a viewing adapter for 1.25" eyepieces.

Solar Prominence Filter $699.95 • 58mm Energy Rejection Prefilter – $169.95 • 77mm Energy Rejection Prefilter – $199.95

Off-Axis Mask for 8" SCT – $69.95 • Off-Axis Mask for Meade 10" – $89.95 • Off-Axis Mask for C11 – $99.95 • Off-Axis Mask for 12" LX200 – $99.95 • Off-Axis Mask for C14 – $119.95 • Off-Axis Mask for M14 – $119.95 • Off-Axis Mask for 16" LX200 – $129.95

MULTIPLE FILTER SELECTOR

The Lumicon 1.25" Multiple Filter Selector lets you switch instantly back and forth between your Lumicon 1.25" filters without having to constantly thread and unthread them from your eyepieces. You may leave one of the 5 slots open to compare filtered and unfiltered views. – $129.95

EASY GUIDERS

All of Lumicon's famous off-axis guiders feature Lumicon's patented radial and rotational off-axis adjustments – combined with a large off-axis pick-off prism, making bright guide star selection a breeze.

CASSEGRAIN EASY GUIDER FOR 7" TO 9.25" SCTs

The Lumicon Cassegrain Easy Guider allows off-axis guiding with your Cassegrain telescope while reducing the f-ratio from f/10 to f/6.3 using a large, fully-coated focal reducing lens. The faster f-ratio, combined with the ease of finding and guiding on bright guide stars, minimizes guiding error, making for successful astrophotos. Threaded for 48mm filters. Specify camera type when ordering.

Celestron 5 – $249.95 • 7" Mak – $249.95 • 8" SCTs – $249.95 • Celestron 9.25" – $249.95

GIANT EASY GUIDER FOR 10" TO 16" SCTs

The Lumicon Giant Easy-Guider is a powerful photo/visual tool, utilizing an 80mm multicoated compression lens to reduce your Schmidt-Cassegrain's f/10 optics to f/6.3 for wide-angle photography. Ideal for 35mm and 120 format film with 100% edge-to-edge illumination and pinpoint star images. All other off-axis guiders have prisms and focal reducing lenses a fraction the size of the Lumicon Giant Easy Guider's. Threaded for all Lumicon 48mm filters. Specify camera type when ordering.

10", 12", 14" and 16" Meade – $399.95 (Meade 16" LX200 requires adapter - $169.95) • 11" and 14" Celestron – $399.95

NEWTONIAN AND REFRACTOR EASY GUIDER

The Lumicon Newtonian and Refractor Easy Guiders allow off-axis guiding directly through the main telescope, thus preventing differential flexure between telescope and guide scope that can ruin your astrophotos. Low-profile design installs in seconds into 1.25" and 2" focusers. Threaded for 1.25" and 48mm filters. Specify camera type when ordering.

1.25" and 2" Newtonian – $189.95 • 1.25" and 2" Refractor – $189.95

LUMICON EASY GUIDER ACCESSORIES

- Newtonian Easy-Guider Focal Reducer Lens in Cell – $79.95
- Giant Easy-Guider Focal Reducer Lens in Cell – $199.95
- Giant Easy-Guider - No Lens – $319.95
- Cassegrain Easy-Guider - No Lens – $219.95

LUMICON 3X RELAY DIAGONAL FOR USE WITH EASY GUIDERS

Lumicon Relay Diagonal's 3x Barlow lens increases the guiding magnification in the off-axis portion of your Lumicon Easy-Guider, increasing off-axis guiding ease and precision. – $99.95

HYPER KITS

LUMICON FILM HYPERSENSITIZATION KITS

Film hypersensitization with a Lumicon Hyper-Kit super-dries your film's emulsion using nitrogen and hydrogen (Lumicon's Forming Gas: 8% prepurified hydrogen, 92% prep. nitrogen, removing ALL water vapor and oxygen molecules, thus thermally stabilizing the film's emulsion. The process also 'soaks' the emulsion with hydrogen, thus sensitizing the silver halide crystals, making them more sensitive to faint light. The combined effect reduces reciprocity failure of the film, allowing it to remain sensitive to light well beyond an hour instead of only a few minutes. Hypered film is a MUST for anyone who is serious about taking deep-sky photographs.

LUMICON MODEL 300 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

For simplest hypering with film still in its metal cassette, the Model 300 Hyper-Kit is easy in use and safe for your film. Operates with Lumicon's Forming gas at 30° C. Hypers film in two to five days.

Chamber Only – $249.95 • Film Hyper Kit – $375.95 • Hyper Kit O-Ring Set – $9.95

LUMICON MODEL 600 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

The versatile Lumicon Model 600 Hyper-Kit is capable of hypering film either while still in its metal cassette at 30° C, or more quickly with highest saturation on the open reel at 50° C. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas.

Chamber Only – $299.95 • Film Hyper Kit – $475.95 • Hyper Kit O-Ring Set – $9.95 • Hyper Kit Hand Vacuum Pump – $39.95 • Hyper Kit Vacuum Pump Handle – $9.95

LUMICON MODEL 1200 FILM HYPERSENSITIZATION KIT FOR 35MM, 120, AND 4x5 FILM

Large-capacity Lumicon Model 1200 Hyper-Kit accepts 4x5 film. Kit is capable of hypering film in just 12-to-20 hours with highest saturation. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas at either 30° or 50° Centigrade for simple or advanced modes of operation.

Chamber Only – $379.95 • Film Hyper Kit – $751.95 • 4x5 Plate Holders – $99.95 • Hyper Kit O-Ring Set – $9.95

HYPER KIT ACCESSORIES

- 4x5 Sheet Film holder – $99.95
- 35L Cylinder of Forming Gas – $145.95
- 30° C Temperature Sensor Probe – $99.95
- 50° C Temperature Sensor Probe – $99.95
- Temperature Controller – $139.95 • Electric Vacuum Pump – $349.95 • 220 V option on Vacuum Pump – $44.95 • 220V/110V Converter – $29.95 • Vac/Pressure Hose with Clamp – $9.95

ASTROPHOTOGRAPHY FILM

HYPERED FILMS

Use Lumicon Hypersensitized Film to take stunning astro photographs. Allows you to expose film on your favorite deep sky object far longer, with no fog buildup, than does non-hypersensitized film.

Fuji G800 – $19.95 • Fuji RD100 – $14.95 • TP2415 B&W – $19.95 • TP6415, 120 – $19.95 • Kodak P1600 – $24.95 • Kodak PPF400 – $19.95 • Kodak PPF400, 120 – $19.95

NON-HYPERED FILM

Lumicon's high-contrast, extremely fine-grained film. High quality for medium-format astrophotography.

TP2415, Bulk 150' Roll – $79.95 • TP2415, Normal 36 exposure – $11.95 • TP4415, 4x5" Normal 25 Sheets – $49.95 • SO-279 Vericolor Slide Film – $14.95 • Kodak 6415, Normal Film – $9.95 • Fuji G800, Normal Film – $9.95 • PPF400, 120, Normal Film – $11.95 • PPF400, 120, Normal Film - 5 pack – $49.95 • Kodak P1600, Normal Film – $19.95 • Fuji Sensia RD100, Normal Film – $9.95

FILM DEVELOPING MATERIALS

- Film Changing Bag – $ 16.95
- Kodak D19 B&W Developer – $ 19.95
- Patterson film developing tank – $19.95

DIAGONALS

ENHANCED ALUMINUM STAR DIAGONALS

The Lumicon Enhanced Aluminum Star Diagonal reflects 96 to 97 percent of the light from the telescope's primary optics into your eyepiece. Its single 1/10 wave precision-polished surface is superior to the three surfaces of prism diagonals, and its enhanced coating is more durable than a standard aluminum coating. Lumicon collimates each star diagonal using a double-pass collimator, ensuring that the light reflected from the diagonal is perfectly perpendicular to the telescope's optical axis. 1.25" – $99.95 • 2" – $189.95 includes 1.25" adapter.

LUMIBRITE STAR DIAGONAL

The Lumicon Lumi-Brite Dielectric-Coated Diagonal reflects >98 percent of the light from the telescope's primary optics into your eyepiece. Not only is the Dielectric Coating more durable than a standard aluminum coating, it is also smoother, resulting in higher image contrast. 1.25" – $149.95 • 2" – $239.95 includes 1.25" adapter

SKY VECTOR

The Lumicon Sky Vector is a state-of-the-art digital setting circle system, providing virtually any astronomical telescope, whether equatorial or altazimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. With the Sky Vector, you will be able to find objects even faster than with most fully computer-driven telescopes. Its alphanumeric display uses a simple, easy-to-read scrolling text format. There is no need to polar align or to enter Latitude, Longitude, Date, Altitude, and Sidereal time – just initialize on one or two stars and you're ready to go!

SKY VECTOR 1

The Lumicon Sky Vector 1 features: One- or two-star initialization; 4000-step encoders for high-resolution accuracy (0.09 deg.); Digital Right Ascension coordinate readout to 1 minute; Digital Declination readout to 10 arc-minutes; Guide mode for guiding you to the selected object in current memory; Database containing over 220 of the finest objects in the sky, including the popular "Messier Catalog."

Complete Set – $349.95 • Kit only – $269.95

LUMICON NGC SKY VECTOR

The Lumicon NGC Sky Vector has all the features of the Sky Vector 1, plus a large 12,000-object database, higher resolution display modes, IDENTIFY mode, and current constellation and chart number displays - all on a 16-digit red LED display. It can be integrated with a personal computer for display of celestial object coordinates.

Complete Set – $489.95 • Kit only – $419.95 • Serial Cable – $29.95

SKY VECTOR UPGRADES

- Upgrade 3.65 Chip Set for NGC Sky Vector. – $59.95
- 8192-Step Encoder Set. Can be purchased separately or in place of the standard 4000 step encoders. – $29.95

LUMICON SKY VECTOR HARDWARE PACKAGES

Lumicon Sky Vector Hardware Package for Meade and Celestron SCTs includes: declination encoder bracket, right ascension encoder holder, encoder shaft holders, Allen wrench, and instructions.

Lumicon Sky Vector Hardware Package for Dobsonian telescopes includes: brass azimuth bolt, stainless steel azimuth encoder bracket, aluminum altitude-encoder-shaft holder, stainless steel altitude encoder bracket, 10 wood screws, Allen wrench, and instructions.

C5+ – $79.95 • C8 – $69.95 • Celestar 8 – $79.95 • Celestar 8 Dlx – $79.95 • G8/G11 – $349.95 • Ultima 8 – $79.95 • Ultima 11 – $99.95 • C11 – $79.95 • C14 – $129.95 • Meade 2080 – $69.95 • 2120 – $79.95 • 8" Dob – $69.95 • 10" Dob – $69.95 • 12/13" Dob – $79.95 • 16/17" Dob – $89.95 • CI700 – $299.95

RICHFIELD VIEWERS

RICHFIELD VIEWER FOR 7" TO 9.25" SCTs

The Lumicon Richfield Viewer takes your Schmidt-Cassegrain's f/10 optics and reduces them to f/6.3 for beautiful wide-field views. Its fully-coated 50mm diameter focal reducing lens has a larger clear aperture and less coma than higher-priced focal reducers on the market, providing superb unvignetted views. Barrel accepts 2" star diagonals. Comes with an aluminum 2"- 1.25" eyepiece reducer, threaded for 48mm filters. – $99.95

RICHFIELD VIEWER, THREADED FOR 7" TO 9.25" SCTs

Threads directly into telescope. – $99.95

RICHFIELD VIEWER, SLIDE-ON, FOR 7" TO 9.25" SCTs

For attachment onto SCTs that have the Lumicon Easy-Guider threaded attachment ring in place. Slides over attachment ring. – $99.95

GIANT RICH-FIELD VIEWERS

LUMICON GIANT RICH-FIELD VIEWER FOR LARGE SCTs

Takes your large Schmidt-Cassegrain f/10 optics and reduces them to f/6.5 for the widest possible views of large galaxies like M31, M33 and NGC 253, and pairs of galaxies like M81 and M82. Moving the 80mm diameter focal reducing lens to the forward position in the Rich-Field Viewer body yields an even wider field. Comes with a 2"- 1.25" eyepiece reducer, threaded for 48mm filters.

10" SCTs – $279.95 • Celestron 11" – $279.95 • 12" SCTs – $279.95

LUMICON 2.5X CCD COMPRESSOR

This cost-effective, fully-coated lens widens the telescope field and yields pinpoint star images for small to medium-size CCD cameras. Has male threads for standard 1.25" eyepieces or camera-type barrels. – $129.95

LUMICON 48MM COMA CORRECTOR FOR NEWTONIAN EASY GUIDER OR 2" EYEPIECE

The Lumicon Coma Corrector lens dramatically reduces coma when used, in particular, with f/3.5 to f/6 Newtonian telescopes. It makes off-axis star images much smaller, thus improving photographic quality and making guiding much easier. Free of all chromatic aberration and fully multicoated to prevent ghost images. Can be used on all 48mm threaded accessories. Neither shrinks nor magnifies the image. – $239.95

LUMICON 1.5x–1.8x MULTIPLIER/FIELD FLATTENER

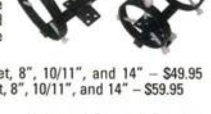
The Lumicon Multiplier / Field Flattener Lens has been custom computer-designed to increase image scale with the flattest field possible for photography and visual use with fast Newtonian Telescopes. This lens is suitable for use with f/3.5 to f/6 systems. Fully multicoated for maximum light transmission. – $259.95

FINDERSCOPE

Lumicon 80mm SuperFinder for Right-Angle viewing. This finder telescope actually lets you see many of the deep-sky objects you are looking for, complementing any telescope having 8 or more inches of aperture. It also makes for a wonderful rich-field telescope for beautiful views of the Milky Way. Comes with 25mm, 1.25" cross-hair eyepiece and helical drawtube-type focuser.

50mm RA Finder - Body Only – $79.95 • 50mm RA Finder - Complete – $149.95 • 50mm Straight-Thru Finder - Body Only – $79.95 • 50mm Straight-Thru Finder - complete – $119.95 • 80mm Right Angle SuperFinder - Body Only – $199.95 • 80mm Right Angle SuperFinder with Tripod Block – $219.95 • 80mm Right Angle SuperFinder - Complete – $299.95 • 80mm Straight-Thru SuperFinder - Body Only – $199.95

FINDERSCOPE BRACKETS



This two-ring finder bracket firmly holds finderscopes to your telescope while allowing precise alignment with the main optical axis. The base is radius-cut to fit snugly against the telescope's main tube, and the dovetail groove makes it easy to install or remove the finderscope from the base. Fastens in brand name SCT telescope mounting holes.

- 50mm Finder Bracket, 8", 10/11", and 14" – $49.95
- 80mm Finder Bracket, 8", 10/11", and 14" – $59.95

- Universal Dovetail Bracket for 50mm finder – $39.95
- 2 traditional universal ring-type brackets for 50mm finder – $19.95

LUMICON 25MM CROSS-HAIR FINDERSCOPE EYEPIECE

This well-made 25mm, 1.25" Kellner single-crosshair finderscope eyepiece is ideally suited for Lumicon's 50mm and 80mm SuperFinders. High contrast and flat field. Non-illuminated. – $69.95

GUIDING EYEPIECE

LUMICON GUIDING EYEPIECE WITH RETICLE ILLUMINATOR

Lumicon's top-quality 12.5mm, 1.25" Orthoscopic eyepiece with focusable dual cross hair for precision guiding. Incorporates new state-of-the-art cordless Reticle Illuminator, featuring rheostatic brightness control and on/off switch.

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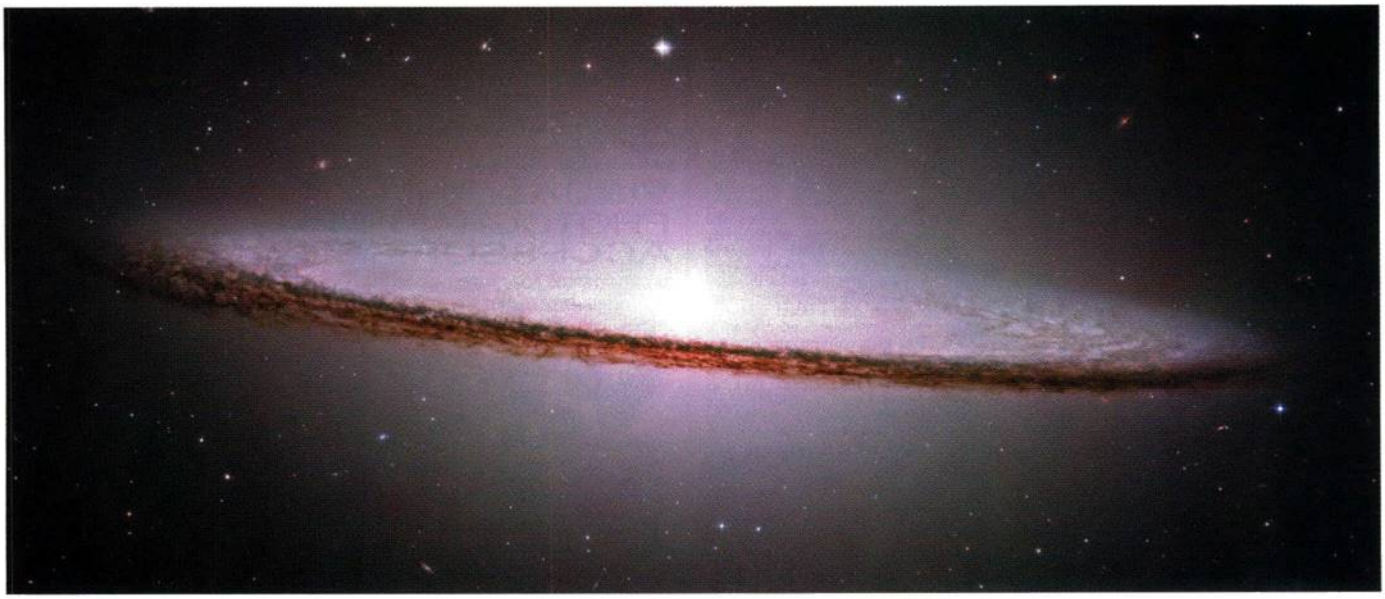
A NASA COMMITTEE HAS CONCLUDED asteroids smaller than half a mile (1 kilometer) in diameter are dangerous enough that they should be found and their orbits tracked. See neo.jpl.nasa.gov/neo/neoreport030825.pdf.

news 01

Read all about it: Old stars in the Large Magellanic Cloud, a butterfly-shaped martian crater, a long-lost asteroid finally recovered, and galactic cannibalism by the Milky Way.



THE LIGHT OF 800 BILLION SUNS shines within the dust ring whose appearance gave the Sombrero Galaxy its nickname. Astronomers estimate the galaxy contains almost 2,000 globular clusters, ten times the number belonging to the Milky Way. At the galaxy's core lies a billion-solar-mass black hole. NASA/STScI

HUBBLE HERITAGE

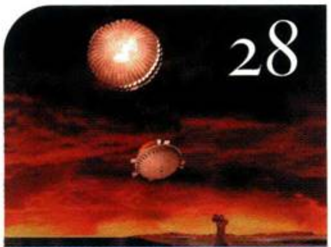
Ringed star-fire: the Sombrero Galaxy

The Sombrero Galaxy (M104) in Virgo is one of the sky's most magnificent galaxies. Recently, the Hubble Heritage project celebrated its fifth anniversary by mosaicking six Hubble Space Telescope images taken in May and June of 2003 into a single portrait.

The Sombrero Galaxy, which shines at 8th magnitude — well within reach of most backyard telescopes — earned its nickname from its appearance in a telescope eyepiece: The dust band in the galaxy's equatorial plane makes it look like a traditional Mexican hat. The effect is enhanced because we view M104 from 6° south of the galaxy's equator.

The Sombrero lies at a distance of some 28 million light-years from Earth, on the edge of the great Virgo-Coma cluster of galaxies.

In 1912, V. M. Slipher at Lowell Observatory took a spectrum of the galaxy. It showed that one side of the Sombrero was approaching us while the other was receding, a clear sign the galaxy was rotating. More important, however, the spectrum showed the galaxy was rushing away at about 700 miles per second. This was one of the first pieces of observational evidence for the expanding universe. In the 1920s and 1930s, that finding was confirmed by the work of Edwin Hubble himself. — **ROBERT BURNHAM**



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30 **Lost asteroid Hermes found after 66 years**

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GALACTIC ASTRONOMY

LMC's old-star halo

A newly discovered halo of RR Lyrae-type variable stars in the Large Magellanic Cloud (LMC) is tantalizing evidence that this smaller, neighboring galaxy may share a similar heritage with our own Milky Way. RR Lyrae variables are ancient pulsating stars scattered in a halo around the Milky Way's periphery.

OLD STARS IN IRREGULAR GALAXIES such as the Large Magellanic Cloud may offer astronomers clues about how all galaxies form. BRUNO MATTERN

An international team of astronomers using the European Southern Observatory's Very Large Telescope monitored 43 RR Lyrae stars originally discovered in the LMC by the MACHO (massive compact halo objects) microlensing project. The high-velocity, random movements of these stars suggest the LMC has a stellar halo similar to the Milky Way's. The finding implies that the LMC and other small, irregular galaxies may have developmental histories that resemble their larger spiral galaxy cousins.

These findings also narrow the possible galactic formation scenarios to just two. Large galaxies may devour smaller galaxies with their old stars completely, thus creating a stellar halo in a process termed hierarchical accretion. Or, before the forming disk of a spiral galaxy collapses, its elderly stellar residents may be violently thrown into its own spherical halo (the rapid collapse model). **— ANDREW FAZEKAS**

Inflatable heat shields: rescue pods?

An old concept from the dawn of the Space Age may soon be validated — and just in time. For decades, it was a solution in search of a problem. But the Columbia shuttle disaster and the ensuing crisis in transportation to and from the International Space Station now provide a reason to revive the idea. The concept is the inflatable heat shield. This would protect a returning spacecraft from atmospheric entry heat not with a rigid, heavy structure but with an insulated balloon. Lighter and more compact than traditional protective systems, the design would be preferable for some missions — if it proves reliable.

For several years, Russian space engineers attempted to establish the design's reliability. Funded by the European Space Agency, they launched three test flights. A fourth flight, scheduled for late 2003, has slipped into early 2004 in order to do more ground testing.

The project, called Demonstrator (more fully, "Inflatable Reentry and Descent Technology," or IRDT), calls for a trash can-size payload to be wrapped in an inflatable shuttlecock-shape balloon that wards off atmospheric heating while slowing the payload for a safe landing.

BAILING OUT FROM ORBIT may be possible with an inflatable reentry capsule, to be flight-tested in early 2004. Primarily intended for cargo, in a pinch, it could rescue astronauts. ESA

On the first mission four years ago, the payload returned intact to Earth despite a puncture, some scorching, and ground-impact damage. Two subsequent tests failed due to rocket failures.

The European Space Agency became interested in this technology several years ago when NASA developed its pricing scheme for transportation to the ISS aboard the shuttle. The charges for "down cargo" — tapes, film, medical specimens, technological samples, etc. — were so high that ESA was concerned its science laboratory, Columbus, would go even farther over budget. Returning the cargo to Earth on small inflatable vehicles deployed out of an airlock may prove cheaper.

With G forces as high as 12, and less accuracy in where the craft lands, the ride definitely would be a lot rougher than on a shuttle or in a Russian Soyuz capsule.

Inflatable heat shields originally were intended as emergency bailout kits for stranded astronauts. And although ESA claims that unmanned down-cargo missions are its main objective, it's clear the design could be modified to bring people back from space as well.

Whether this idea ever becomes acceptable for emergency crew return, or even for extreme-sports space skydiving, will depend on the next test flight. If it fails, the idea may be shelved for another generation. **— JAMES OBERG**

RELATIVITY TOOK A TEST using radio signals from the Cassini spacecraft. Scientists measured the frequency change in Cassini's signals as they passed close to the Sun; the effects matched relativity's predictions.

LUNAR SCIENCE

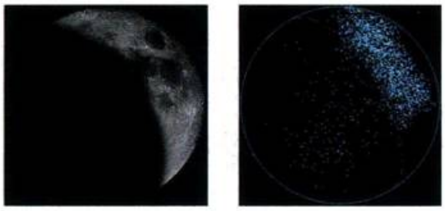
Moon prospecting

Lunar observations with the Chandra X-ray Observatory have found oxygen, magnesium, aluminum, and silicon over many areas of the Moon's surface.

X rays from the Sun strike the Moon, causing atoms in rocks to fluoresce. The spectra of the X rays let scientists identify the specific elements involved.

The X rays seen on the unilluminated part of the Moon, on the left side of the image below, are not lunar. They are X rays produced in the highly tenuous atmosphere that surrounds the Chandra observatory itself. — **R. B.**

LUNAR X RAYS (below right) are helping scientists map the surface distribution of the Moon's elements. R. GENDLER (L) AND NASA/CXC (R)



OBSERVATORIES

Discovery telescope

Lowell Observatory and the Discovery Channel are collaborating to build a new $30 million telescope. The instrument will have a 4-meter aperture.

The telescope's scientific goals are primarily the discovery of near-Earth asteroids and Kuiper Belt objects. The telescope also will study extrasolar planets, brown dwarfs, massive stars, and galactic structure.

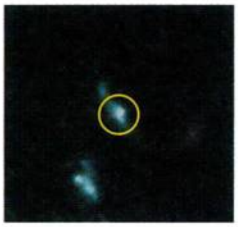
Construction begins in autumn 2004, with completion set for 2008. — R. B.

A NEW 4-METER telescope at Lowell Observatory will have a wide (2°) field of view. LOWELL OBS.

HIGH-ENERGY ASTROPHYSICS

X-ray flash theory dashed

When relatively short bursts of X rays called X-ray flashes (XRFs) were discovered three years ago, some astronomers thought they might be very distant gamma-ray bursts (GRBs) that had lost energy traveling through space.



THE AFTERGLOW of XRF 020427 appeared in a faint galaxy (circle). NASA

Now, that idea has been ruled out by the discovery of two nearby XRFs. A consortium of powerful telescopes helped astronomers pinpoint the hosts of the XRFs, which were detected on October 30, 2001, and April 27, 2002. The hosts were faint blue galaxies that lie between 6 billion and 11 billion light-years from Earth.

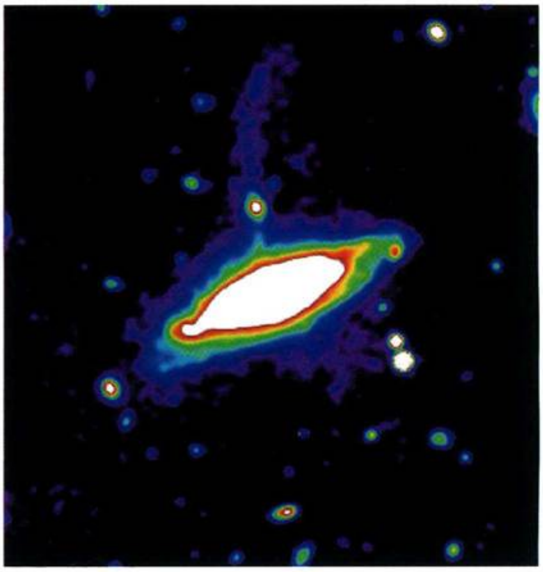
The distant GRB hypothesis "was exotic but a dead end," says Joshua Bloom, an astronomer at the Harvard-Smithsonian Center for Astrophysics and lead author of a paper on the results in the *Astrophysical Journal.*

The next step is to figure out what causes XRFs — they may be lower-energy cousins of GRBs or, perhaps, GRBs seen from an oblique angle.

— **MAGGIE McKEE**

GALACTIC ASTRONOMY

Big galaxies are hungry



THE PURPLE PLUME shows stars being torn from a dwarf galaxy as it collides with a larger galaxy's halo. NASA/STScI

Astronomers using the Hubble Space Telescope have photographed a large spiral galaxy devouring a dwarf galaxy. The image shows a plume of stars being ripped out of the dwarf by the gravitational force of the larger galaxy's extended halo of dark matter.

A team led by Duncan Forbes (Swinburne University) imaged the pair, which lies about 2 billion light-years away. Following the observations, computer simulations of the collision showed that the dwarf galaxy had already made several circuits through the bigger galaxy, losing stars with each pass. And the simulations showed that several more passages through the large galaxy's disk lie ahead for the dwarf before the bulk of its stars have been absorbed.

An identical process is going on in the Milky Way, as our galaxy tears down the Sagittarius dwarf galaxy to its component stars.

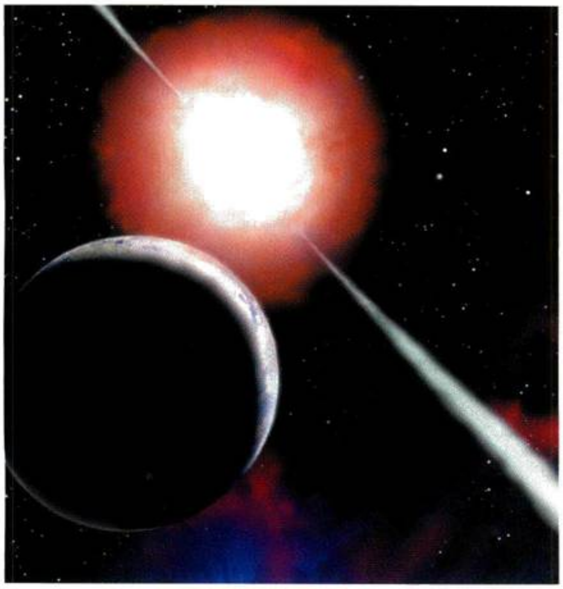
Steven Majewski (Univ. of Virginia) led a team that examined data from the Two-Micron All Sky Survey (2MASS), an infrared inventory of the whole sky.

"Both stars and star clusters that are now within the outer Milky Way have been stolen from Sagittarius," he says. "This example shows the Milky Way grows by eating its small neighbors." — **R. B.**

THE SOLAR SYSTEM'S MOON-O-METER has clicked over again, with four new moons discovered orbiting Uranus (new total: 27) and an additional one at Neptune (new total: 13). See www.ifa.hawaii.edu/~sheppard/satellites/.

TERRESTRIAL EXTINCTIONS

Killer gamma-ray bursts?



A NEARBY GRB might have wiped out about 100 families of marine invertebrates 440 million years ago. CfA/DAVID AGUILAR

Here's a scary thought: The list of celestial objects that can obliterate life on Earth is growing. An asteroid that struck Mexico 65 million years ago probably annihilated the mighty *T. rex* and his kin, and now, astronomers believe a nearby gamma-ray burst (GRB) caused a devastating mass extinction at the end of the Ordovician period about 440 million years ago.

Most GRBs are thought to arise from laser-like jets that shoot out from massive stars collapsing into black holes and lie about 10 billion light-years away. But sometimes, GRBs can pop off too close for comfort: Last March, a bright GRB about 2.6 billion light-years away briefly ionized Earth's upper atmosphere.

Such nearby GRBs are rare — perhaps five explode within a few thousand light-years of Earth every billion years — but deadly. In the Ordovician period, all life on the planet was aquatic, and fossil records show that species living in deeper water fared better than shallow-water dwellers. Cosmologist Adrian Melott (Univ. of Kansas) and colleagues believe a close GRB could provide an explanation — radiation zapped at Earth would break apart atmospheric molecules, letting damaging UV light through to creatures near the water's surface.

This mechanism, says J. E. Horvath (Univ. of São Paulo), also may have caused a major extinction at the start of the Cambrian period, 544 million years ago. Many new life-forms appeared in its aftermath. — **M. M.**

SOLAR SYSTEM

Tracing early rocks

Molybdenum, a trace element used to strengthen steel, may hold clues to how the solar system formed. Studies of the most ancient meteorites indicate that the abundance of the rare metal can be linked to the conditions that prevailed in the solar nebula during its early years.

A planetary system starts life as a disk of dust and gas around a protostar. Easily influenced by heat of the infant Sun, the disk's raw materials mingle and become imprinted with specific isotopes of elements. Understanding the scale and amount of mixing can shed light on the early development of these disks.

Harry Becker and Richard Walker (Univ. of Maryland) found molybdenum isotopic fingerprints to be similar in both primitive meteorites and terrestrial rocks, implying that the two formed at the same time. The scientists suggest the primordial granules experienced "efficient mixing of gas and dust in the solar nebula at least to 3 AU," making a well-blended inner solar system. — A. F.

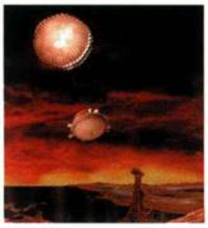
SOLAR SYSTEM

Glints from Titan's surface

Astronomers have blasted Saturn's moon Titan with radar and found the best evidence yet for lakes. A team led by Don Campbell of Cornell University used the huge 305m Arecibo and 100m Green Bank radio telescopes to receive faint echoes two hours after transmitting the radio beams toward Titan.

Some echoes indicated reflections from flat, dark areas — most likely lakes of methane which, like water on Earth, may form clouds, rain, rivers, and seas under Titan's thick atmosphere.

Next year, the NASA/ESA Cassini mission will explore Titan with cameras and radar, and its Huygens probe will parachute down — landing perhaps in a splashdown.
— **RALPH LORENZ**



WILL LAKES or land greet the Huygens probe at Titan? Radar suggests lakes. NASA/JPL

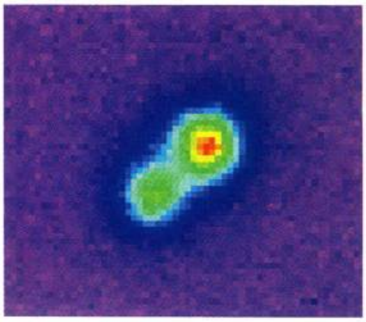
BROWN DWARF STARS

Epsilon Indi B has a companion

Brown dwarfs are small, cool stars that barely shine. Epsilon Indi B, lying 11.8 light-years from the Sun, is the closest such star to Earth. Astronomers using the Gemini South telescope in Chile recently discovered that Epsilon Indi B has a companion brown dwarf orbiting it at a distance of 2.7 AU. Epsilon Indi Ba and Bb (as they are now designated) have masses of about 40 and 30 Jupiters, respectively.

The surface temperature of Epsilon Indi Ba is around 2200° Fahrenheit; Bb is about 1500° F.

The discovery was made accidentally as astronomers led by Gordon Walker (Univ. of British Columbia) took images of Epsilon Indi B — and noticed a second, dimmer source close to it. — **R. B.**



A COOL GLOW [lower left] marks the companion that makes Epsilon Indi B a brown dwarf pair. GEMINI OBSERVATORY

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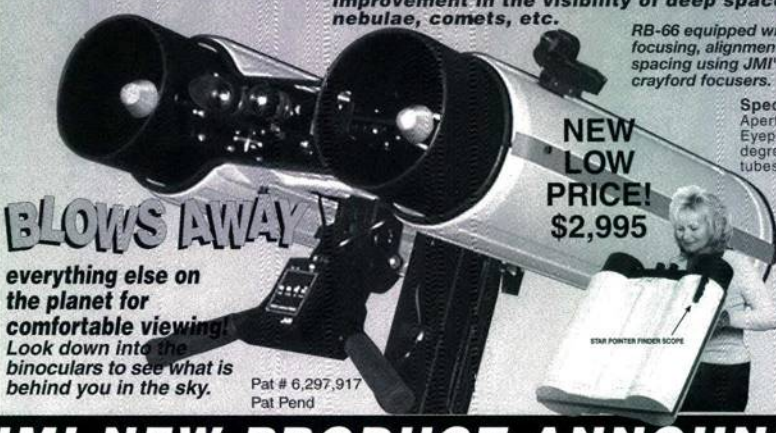
Twin 6" f/5 Newtonians, 150mm x 20-125 depending on eyepieces

USING BOTH EYES IMPROVES CONTRAST 40%. Tremendous improvement in the visibility of deep space objects like galaxies, nebulae, comets, etc.

RB-66 equipped with six motors, two each for focusing, alignment of optical tubes and interocular spacing using JMI's famous patented reverse crayford focusers.



everything else on the planet for comfortable viewing!
Look down into the binoculars to see what is behind you in the sky.

Pat # 6,297,917
Pat Pend

Specifications
Aperture: Primary mirrors 6" f/5
Eyepieces: Two 20mm wide-angle, 1.4 degree field Clearance between optical tubes: 10" Battery supplied: 6vDC

RB-66 $2,995
(Includes eyepieces and tripod)

OPTIONAL ACCESSORIES
POCKET PC with TheSky Pocket Edition (call for info)
Case $279.95 ($29)
NGC-microMAX $399 ($8)

JMI NEW PRODUCT ANNOUNCEMENT

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The case has a padded shoulder strap, handle grip and two zipper compartments for carrying small accessories. It fits the Standard Meade Field Tripod for 10" and smaller scopes. Also fits tripods up to 38" long (folded) and 10" in diameter.
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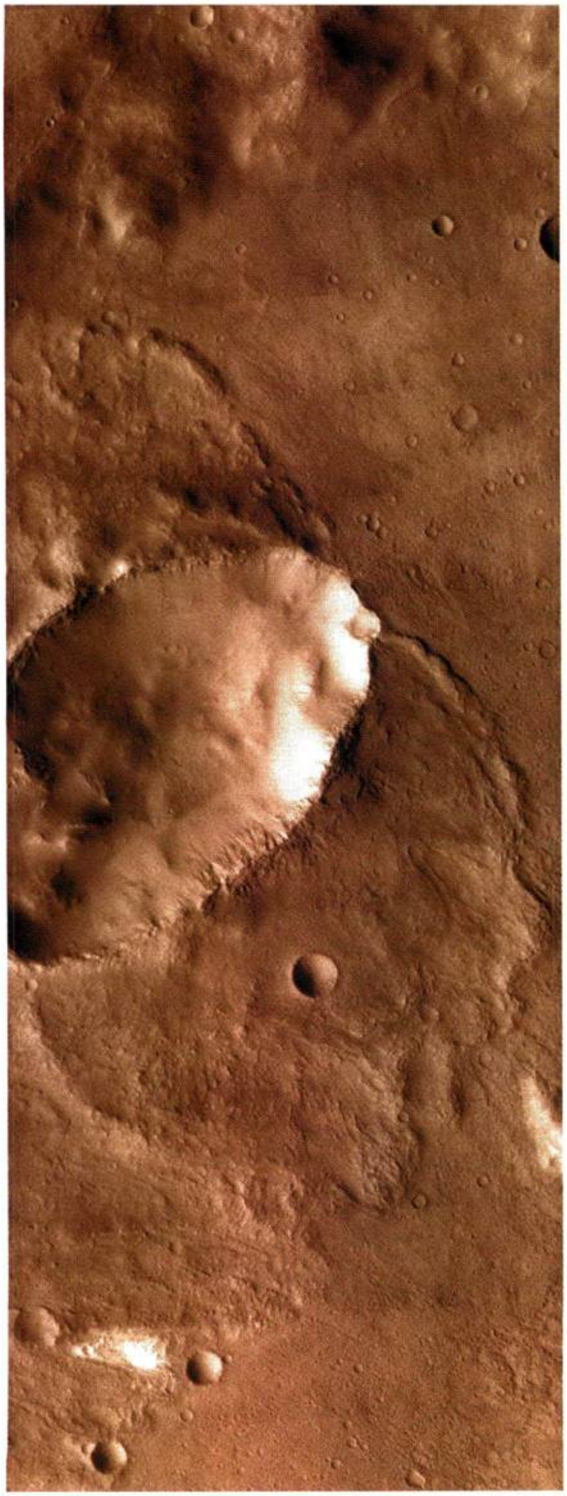
10,000 NEW IMAGES from the Mars Global Surveyor have been posted on-line at www.msss.com/moc_gallery/, bringing the total to more than 134,000. For the latest images from Mars Odyssey, see themis.la.asu.edu.

Butterfly crater



AN IMPACT from a small asteroid that hit at a shallow angle created this symmetrical pattern of ejecta. The crater lies north of Argyre and measures about 6 by 9 miles. NASA/JPL/ASU/IMAGE 20030904A

SOLAR SYSTEM

Hermes recovered

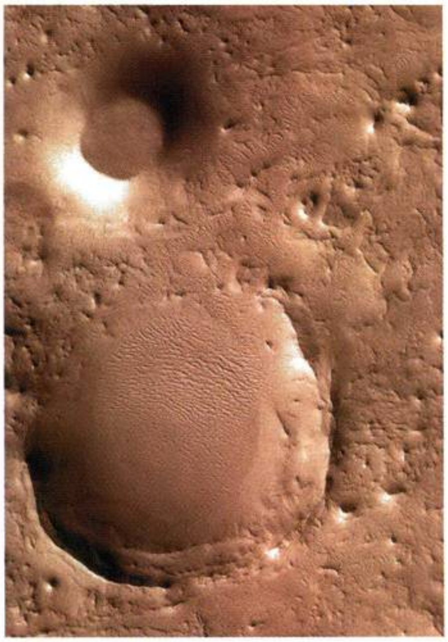
Hermes, an Earth-approaching asteroid last seen 66 years ago, has finally been recovered. Brian Skiff (Lowell Observatory) found a near-Earth asteroid on October 15, 2003, that proved to be the long-lost Hermes.

Hermes was discovered in 1937, but tracked for only five days before being lost.

In 1937, Hermes passed within 500,000 miles (800,000 km) of Earth. Its latest pass took it about nine times farther away. Radar observations since recovery show that Hermes is two separate objects in mutual orbit, each about 1,300 feet (400 m) across. Hermes continues to pose a threat to Earth, although no encounters loom for at least a century. — R. B.

ASTEROID HERMES, lost since 1937, has finally been found again. DAVID HEALY

MARS PHOTOJOURNAL



A CIRCULAR MESA in northeastern Arabia Terra and the larger bowl-shaped feature seen below it share the same origin. Both are impact craters, but the smaller crater was filled with debris that has resisted weathering. The result is a mesa. The larger crater is emerging as erosion, probably by wind, is stripping away the surface materials. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE R08-00024

COMETS

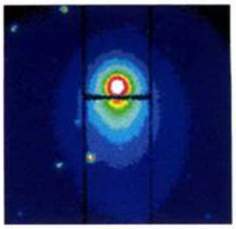
"Heavy" nitrogen found in comets

A team of planetary scientists using an 8.2-meter telescope at the European Southern Observatory have made the first identification of "heavy" nitrogen in a comet. This isotope of nitrogen is rare and difficult to detect.

Spectra of Comet LINEAR (C/2000 WM1) revealed the substance. The observation also helped the team, led by Claude Arpigny (Univ. of Liège), confirm an earlier, marginal detection of the same nitrogen isotope in Comet Hale-Bopp.

When the team measured the abundance of the isotope, they found the comets had nearly twice the heavy nitrogen typically found in terrestrial materials.

These results suggest that the early solar system, of which comets are relatively unspoiled samples, had a richer mix of elements than scientists previously suspected. The results also support the idea that comet impacts gave the young Earth materials essential for creating life. — A. F.



LIFE LIKELY BEGAN on Earth with organic chemicals brought by comets such as C/2000 WM1. ESO

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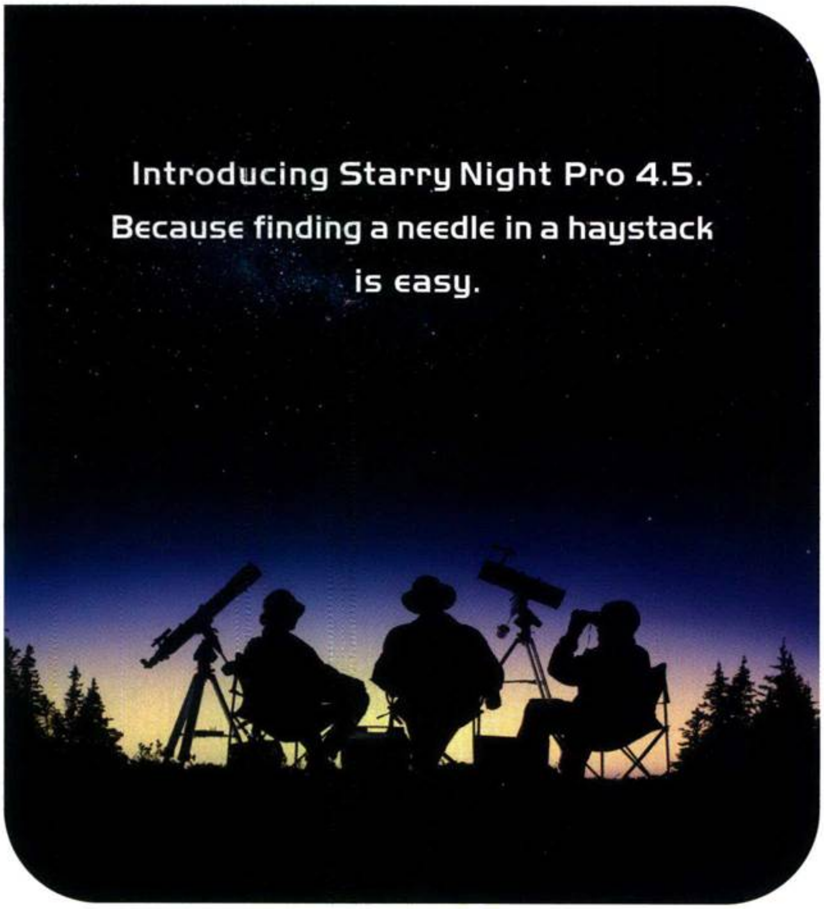

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SkyQuest XT6 IntelliScope

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Only **$359**
(IntelliScope Controller sold separately)

SkyQuest XT8 IntelliScope

The world's best-selling 8" Dobsonian, the XT8, boasts newly enhanced features, including IntelliScope object-location capability. Features a 203mm parabolic primary mirror (1200mm f.l., f/5.9) that reaches deep into space for jaw-dropping images of the planets, nebulas, clusters, and galaxies. Features 2" aluminum focuser, 9x50 finder scope, springless CorrecTension, two Sirius Plössl eyepieces, and more.

Only **$479**
(IntelliScope Controller sold separately)

SkyQuest XT10 IntelliScope

The XT10 takes another giant leap forward. With its dazzling optics, a contemporary new design, and IntelliScope computerized pointing capability, it's a scope that will thrill for a lifetime. Features a 254mm Pyrex parabolic mirror (1200mm f.l., f/4.7), 2" aluminum focuser, 9x50 finder scope, springless CorrecTension, two Sirius Plössl eyepieces, and more.

Only **$649**
(IntelliScope Controller sold separately)

IntelliScope™ Controller
(Optional)

Locate and view any of more than 14,000 celestial objects in seconds! With this optional Controller, you just select an object to view, press Enter, then move the telescope in the direction of the guide arrows on the backlit LCD screen. In seconds, the object will be smack-dab in the telescope's field of view. Easy!

Only **$149**

SkyView™ Pro Telescopes

Special Offer!

Order now and receive a FREE TrueTrack™ single-axis drive or save $70 off a TrueTrack™ dual-axis drive.

SkyView Pro 6LT

For anyone interested in extra magnifying power for viewing lunar terrain, Jupiter's bands, Saturn's rings, or double stars, the 6LT will get the job done. The 150mm, 1200mm focal length (f/8) parabolic primary mirror delivers 60% greater magnification than you get from shorter models using the same eyepiece. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 6LT & FREE drive
$469

SkyView Pro 8

Finally, a telescope that gives views that will blow you away without blowing your budget! A full 8" (203mm, f/4.9) parabolic primary mirror, which gathers 73% more light than a 6". The tube features a 2" aluminum rack-and-pinion focuser and a sturdy 4-vane holder. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 8 & FREE drive
$549

SkyView Pro 120

Love refractors? We've combined our 120mm achromatic refractor with our super-sturdy SkyView Pro mount. The big fully multi-coated 120mm (f/8.3) objective lens and 2" focuser will give you jaw-dropping views of the skies. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), 90° star diagonal, collimation tool and dust-cap.

SVP 120 & FREE drive
$549

SkyView Pro 127

Given the popularity of our 127mm Mak, it's only natural that we offer it with the best new mid-sized equatorial mount in the market, the SkyView Pro. The 5" Maksutov-Cassegrain optics pull in plenty of light for great views of deep-sky gems. And you can't beat its long focal length of 1540mm (f/12.1) for high-magnification study of the Moon and planets. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces, (25mm and 10mm), 90° mirror star diagonal, optical tube carry case and dust-cap.

SVP 127 & FREE drive **$649**

Orion 80mm ED Refractor

Finally, a premium "apo" you can actually afford! With a focal length of 600mm (f/7.5), the "ED80" is wonderfully suited for visual applications as well as for film or CCD imaging. Fully multi-coated 80mm objective doublet, with one element made from Extra-Low Dispersion, or "ED" glass for superior color correction. Backlash-free, 2" Crayford-style focuser. Just 24" long. Tube assembly only, without accessories.

Only **$429**

Atlas 10 Reflector

This celestial cyclops will enchant for a lifetime. Our biggest optical tube (254mm, f/4.7) on our beefiest mount will give you incredible images. Dual internal drives built in to the mount. Includes 9x50 finder scope, polar alignment scope, 25mm (48x) and 10mm (120x) 1.25" Sirius Plössl eyepieces, 2" collimatable focuser w/ 1.25" adapter, prime-focus camera adapter with T-thread, multi-speed hand controller, collimation cap and dust cap.

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ACCESSORIES

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Orion Dynamo™ 12-Volt DC Rechargeable Power Station

Power your motor-driven telescope and electronic accessories with this versatile, portable 12V DC power supply. The Dynamo is a sealed, fully rechargeable, 7-amp-hour battery with dual 12V DC "cigarette lighter" output ports (10 amps max.), plus 3V, 6V, and 9V DC male pin jack outputs (1 amp max.). With built-in flashlight with red lens cover and a bright, 55-watt hinged spotlight. Includes 110V AC and DC charging adapters and shoulder strap.

$56.95

New!

Orion V-Block™ Anti-Fringing Filter

The Orion V-Block filter effectively removes distracting color halos from around bright objects, greatly improving image sharpness, color, contract, and resolution. Works well with achromatic refractors of any aperture or focal length. Threads into eyepieces, diagonals, and barlow lenses that accept 1.25" or 2" filters.

1.25" V-Block Filter	**$69.95**
2" V-Block Filter	**$89.95**

SkyView™ Pro EQ Pier Mount

Our SkyView Pro equatorial head is now available on a beefy pier pedestal. In our tests, the pier edged out the tripod version of the SVP mount for stability, and that's no small feat! Credit the 4"-diameter steel pillar and the girder-like, 16.5" steel strut legs. The legs clamp on rigidly with just three bolts (total), for quick setup and take-down. Removable castors let you roll the mount on hard surfaces. Large leveling bolts on the legs provide a firm, level stance. Height at top of EQ head, 4' 1". Optional 16" Pier Extension available. Weighs 73 lbs.

New!

$449

Steel Pier Pedestal (Only)

Includes adapter plate for SkyView Pro equatorial head. Height, 34-3/4". Weighs 47 lbs.

$249

Orion Aluminum Focus Wheels

New!

Replace those standard plastic focus knobs with these stylish aluminum wheels, complete with rubber grip. They fit most Orion telescopes and many other competitors' scopes (see telescope.com or call for list). Set of two wheels with mounting screws.

$19.95

Shorty™ 2x Barlow Lens

This compact barlow is just 2-7/8" long, about half the length of a regular barlow, for greater convenience and versatility. Fits all 1.25" telescope eyepieces. Features a multi-coated, baffled achromatic lens system.

$39.95

RockStable™ Anti-Vibration Pads

Special visco-elastic material reduces vibrations from wind and other sources. Put under tripod legs for steady images. Ideal for both visual astronomy and astrophotography. Sold in sets of three.

$48.95

New!

Orion LaserMate™ Deluxe Laser Collimator

The LaserMate Deluxe Collimator makes collimation a simple, one-step procedure. A "rear view" port in the aluminum housing lets you see both the emitted and return beams while standing at the rear of the telescope. Just tweak the collimation bolts until the beams overlap for laser-precise collimation at lightning speed.

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Ideal for any reflector. Fits any 1.25" eyepiece holder. Just 5 3/4" long.

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Orion Helical Fine-Focusing Adapter

This precision-machined adapter makes fine focusing a breeze. It replaces the 2"-to-1.25" eyepiece adapter in scopes equipped with a 2" focuser, allowing very fine helical focusing with just a feather touch. Features dual rubber grip rings and setscrew lock. Works with 1.25" eyepieces. Requires at least 9mm inward focus travel.

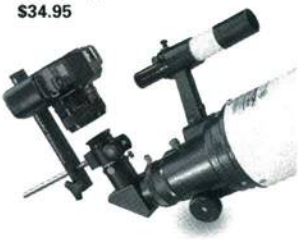
New!

$44.95

SteadyPix™ Universal Camera Mount

This nifty device couples any digital or film camera to the eyepiece of any telescope for through-the-eyepiece photography. Attaches directly to any standard 1.25" telescope eyepiece. Camera threads on to a 1/4"-20 pedestal via the threaded hole in the camera body.

$34.95



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Protect your investment with a padded, polyester/nylon case. Strap handles for easy carrying. Many sizes.

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Orion® Electronic Imaging Eyepieces

View real-time images from your telescope on a T.V. set! Each unit contains a CCD detector similar to the chip in a video camcorder (1/4"-square CCD chip with a 320x240 pixel array in the monochrome eyepiece and a 1/3"-square CCD chip with a 510x492 pixel array in the color eyepiece). Each includes a 9-volt alkaline battery and RCA cable.

New!

Monochrome Electronic Eyepiece	**$64.95**
Color Electronic Eyepiece	**$119**

Orion DeepView™ 2" Deep-Sky Eyepieces

Unprecedented affordability in quality 2" eyepieces! DeepView 2" eyepieces deliver wondrous wide-field views of nebulas, galaxies, and sprawling star clusters. They feature anodized aluminum housings and a 3-element lens design with multi-coatings for efficient light transmission. Eye relief is a long 20mm — a welcome spec for eyeglass wearers. Apparent fields of view for the 35mm and 42mm models are a generous 56o and 52o, respectively. Delightfully free of pincushion distortion and chromatic aberration, DeepView eyepieces will impress even the seasoned deep-sky observer.

35mm, 42mm **$74.95 each**

Expanse™ Wide-Field Eyepieces

With their 66° apparent field of view, our Expanse wide-field eyepieces will definitely turn up the Wow! factor in your deep-sky observing experiences! Imagine taking in objects like the Andromeda Galaxy, the Double Cluster, or the star clouds in Sagittarius in one sweep! With an Expanse in your focuser, you can! Fully coated, rubber eyeguards.

6mm, 9mm, 15mm, 20mm	**$49.95 each**

Sirius™ Plössl Eyepieces

You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. Fully-coated optics, rubber eyeguards.

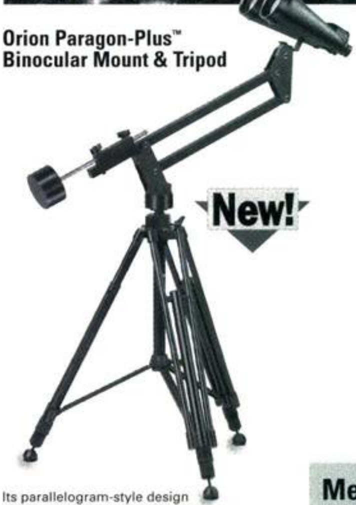
1.25"

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm	**$42.95 each**
32mm, 40mm	**$47.95 each**

BINOCULARS

Orion Paragon-Plus™ Binocular Mount & Tripod

New!



Its parallelogram-style design and silky smooth motion allows oh-so-comfortable viewing for hours on end with binoculars as large as 80mm in aperture. It holds the binocular for you, eliminating arm strain and shakiness, and allows you to aim it high overhead — even to the zenith — while you stand or sit comfortably underneath. You can raise and lower the binocular while staying fixed on a target.

Solidly constructed of aluminum. Features tension knobs, sliding counterweight for perfect balance, and 1/4"-20 L-adapter. Includes the sturdy Paragon-Plus XHD aluminum tripod. And you get the whole package for an unprecedented low price!

Only **$279**

Binocular Mount only, without tripod.

Only **$189**

Orion Mini Giant™ Binoculars

Ideal for binocular astronomy, these Mini Giants deliver bright images of celestial objects without the weight or bulk of larger binoculars. BAK-4 prisms are fully multi-coated; aluminum barrels are internally glare-threaded. Eyepiece design yields long eye relief for viewing comfort. Includes hard case, wide neck strap and lens caps.

8x56 Mini Giant	**$159**
9x63 Mini Giant	**$189**
12x63 Mini Giant	**$209**
15x63 Mini Giant	**$219**

MegaView™ 80mm Binoculars

Premium giant binoculars with high-power optics and cross-reinforced aluminum body and sliding tripod mounting post for optimum balance. Fully multi-coated 80mm lenses with BAK-4 prisms. Long eye relief. made in Japan.

15x80 3.5° field	**$429**
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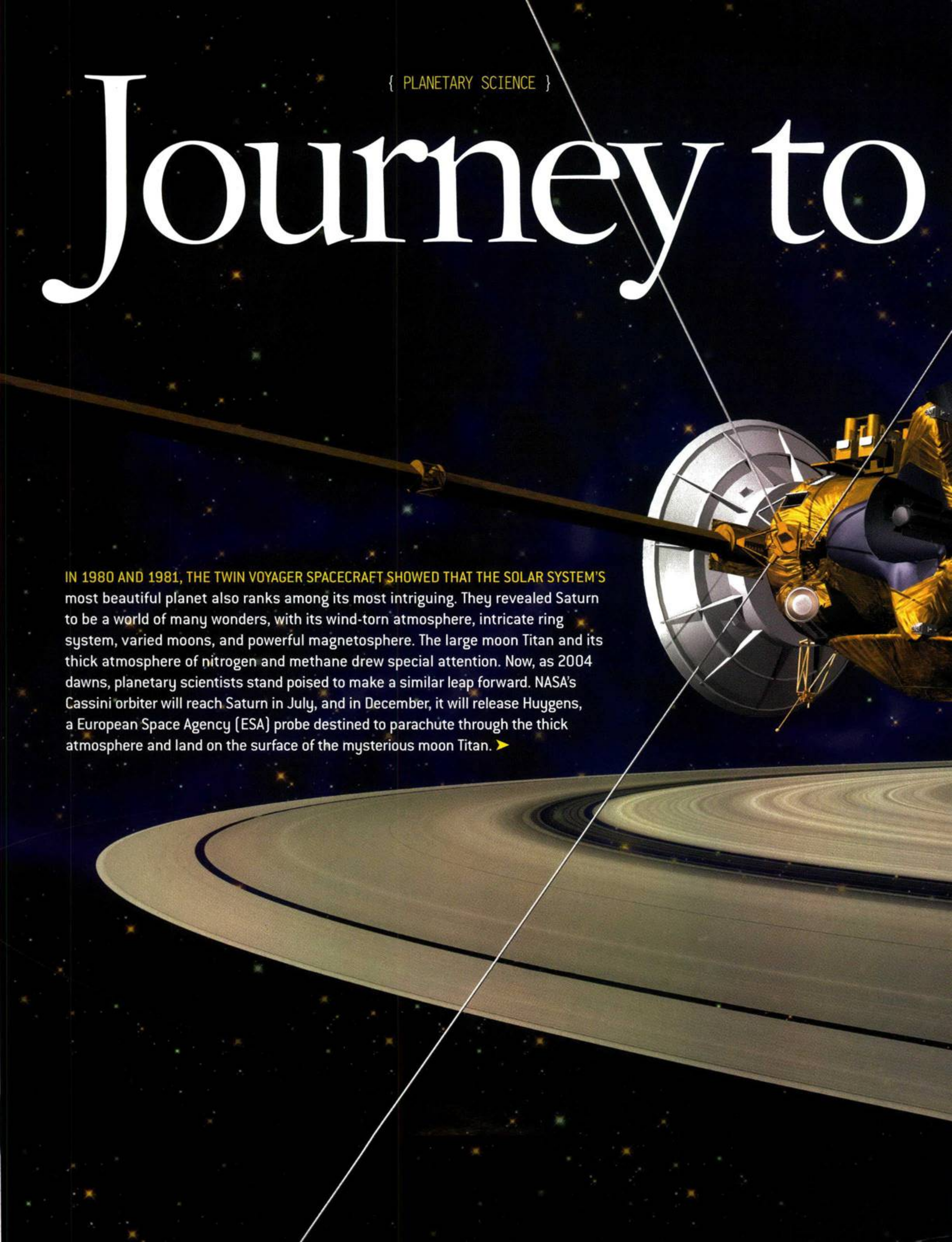
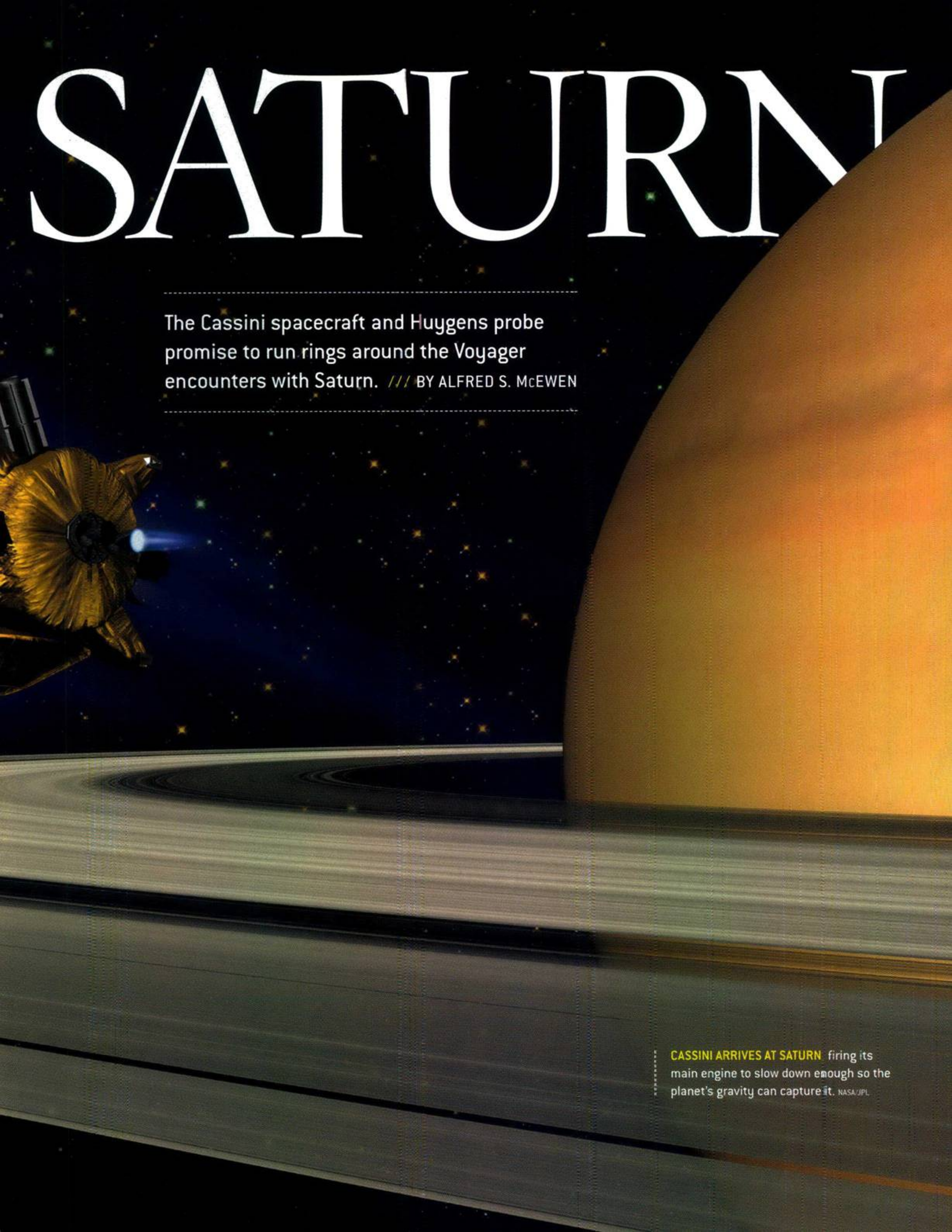


IN 1980 AND 1981, THE TWIN VOYAGER SPACECRAFT SHOWED THAT THE SOLAR SYSTEM'S most beautiful planet also ranks among its most intriguing. They revealed Saturn to be a world of many wonders, with its wind-torn atmosphere, intricate ring system, varied moons, and powerful magnetosphere. The large moon Titan and its thick atmosphere of nitrogen and methane drew special attention. Now, as 2004 dawns, planetary scientists stand poised to make a similar leap forward. NASA's Cassini orbiter will reach Saturn in July, and in December, it will release Huygens, a European Space Agency (ESA) probe destined to parachute through the thick atmosphere and land on the surface of the mysterious moon Titan. ➤

SATURN

The Cassini spacecraft and Huygens probe promise to run rings around the Voyager encounters with Saturn. /// BY ALFRED S. McEWEN



CASSINI ARRIVES AT SATURN firing its main engine to slow down enough so the planet's gravity can capture it. NASA/JPL

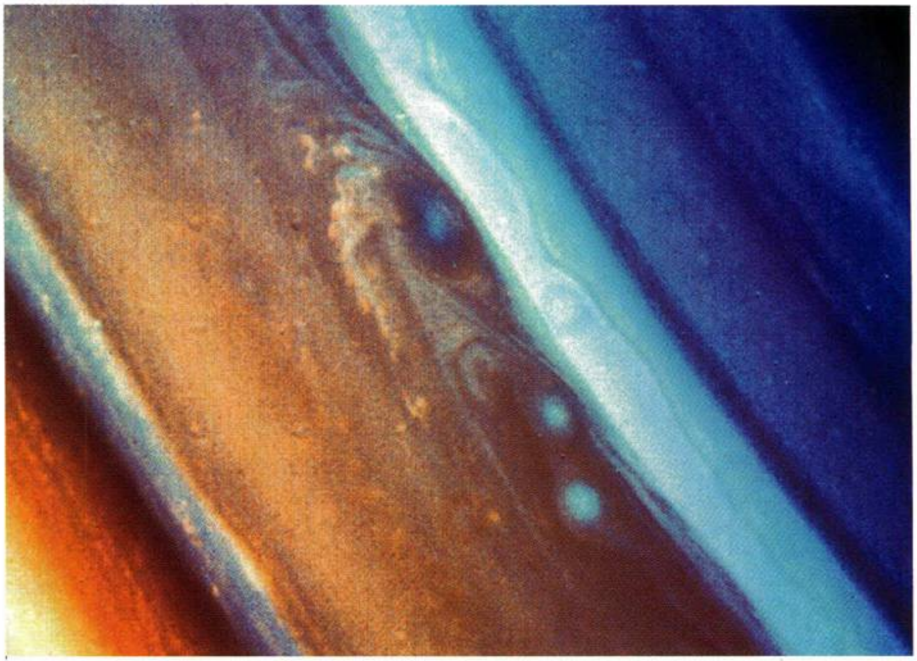
THIS IS A BIG MISSION, CONCEIVED and started before NASA's mantra of "faster, cheaper, smaller" came into vogue. The Cassini orbiter contains a dozen experiments and Huygens has half as many, some with multiple instruments.

Cassini started off as part of an even larger program that included the Comet Rendezvous Asteroid Flyby (CRAF) mission. But budget cuts led to CRAF's cancellation and reductions to Cassini. Cassini was supposed to have a scan platform, like the Voyagers and Galileo, so it could keep its high-gain antenna pointed at Earth while aiming its experiments in many directions. But to reduce mass and cost, all the instruments were mounted on the body of the spacecraft, so the whole "Battlestar Galactica" (as former NASA administrator Dan Goldin is said to have called it) has to turn to make science observations. That means the high-gain antenna doesn't point at Earth most of the time, and spacecraft software will be called on to diagnose errors if something goes wrong. Scientists usually want to orient their experiments in different directions — often simultaneously — which enormously complicates mission planning. Still, the science harvest promises to provide a real feast.

TRIUMPH OVER ADVERSITY

The mission got underway on October 15, 1997, when a Titan IV-B/Centaur rocket blasted off from Cape Canaveral with its 6-ton cargo of hardware and fuel. The launch was controversial because Cassini's power generators use plutonium, even though the generators were engineered to withstand launch failure without contaminating the environment. Cassini followed a 6.7-year trajectory to Saturn that included gravity assists from Venus (twice), Earth, and Jupiter.

In February 2000, an in-flight test of Huygens revealed a major problem. The Huygens receiver on the orbiter, which collects the probe's data before the main spacecraft relays it to Earth, didn't have enough bandwidth. The relative motion of Cassini and Huygens introduces a Doppler shift in the probe's signal. If the two spacecraft are moving away from each other, the wavelength grows longer (a redshift); if they're approaching each other, the signal shifts to a shorter wavelength (a blueshift).



SATURN'S ATMOSPHERE CHURNS as winds blow at nearly 600 miles per hour. Cassini will shoot movies of the saturnian system that will enable scientists to study the planet's dynamics. NASA/JPL

Although scientists know the Doppler shift all too well, somehow it was overlooked in the design of the Huygens receiver. The only way to reduce this problem to an acceptable level was to decrease the two spacecrafts' relative speed. This meant changing the mission's flight path through the saturnian system to raise the orbiter's altitude when the probe encounters Titan. So instead of releasing the probe at the first Titan flyby, mission planners will wait until the third. Ironically, the delay may bring additional benefits, such as enabling scientists to understand Titan's winds better before they release the probe.

The flyby of Jupiter in late 2000 and early 2001 also proved valuable. Although studies of Jupiter were not in the budget, the Cassini team recognized the value of a full dress rehearsal before encountering Saturn. In reality, it was more like a "half-dressed rehearsal," but the team learned important lessons. For example, one of the four reaction wheels used to aim the spacecraft wasn't working properly. (Three wheels are necessary, while the fourth serves as a backup.) Worsening problems led scientists to replace the balky wheel with its backup. If a second wheel fails, the mission will be significantly compromised.

Notable science results have been published from the Jupiter encounter, and a full analysis of the data will produce more. The cameras of the Imaging Science Subsystem (ISS) yielded spectacular images of Jupiter and its large moons. Shortly after the encounter, however, mission engineers sent a command to heat the instrument, decontaminating it by driving off any volatile substances that might have collected. The first twelve decontamination runs since launch had gone without a hitch, but the thirteenth, which heated the instrument to a higher temperature than earlier runs, proved unlucky. Images from the ISS narrow-angle camera looked fuzzy. Instead of showing stars as points of light, they became broad smears. The heating had somehow released volatile materials in the camera system and deposited them on the CCD or a nearby optical surface. Fortunately, a careful program of subsequent heating eliminated the optical fuzz, and the images are sharp once again.

MYSTERIOUS TITAN

The Voyager missions taught us a great deal about the atmosphere of Titan, but they didn't let us study the moon's surface in detail. Voyager's infrared spectrometers detected traces of propane, ethane, acetylene, and other hydrocarbons. In addition, Voyager found methane, which, at Titan's temperature, will condense out of the atmosphere and "rain" onto the surface. This led scientists to predict oceans of hydrocarbons on the moon. Recent

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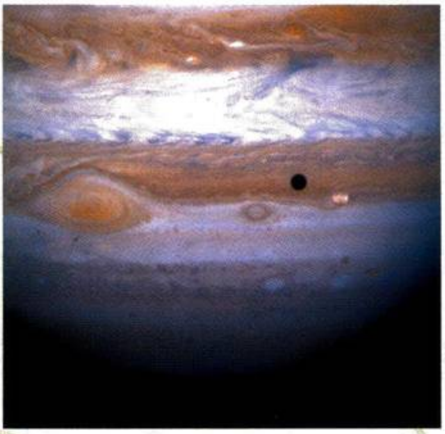
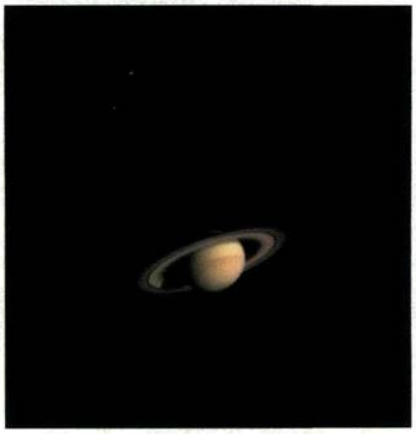
Alfred S. McEwen *is a planetary scientist at the University of Arizona. He belongs to the Cassini mission's imaging team.*

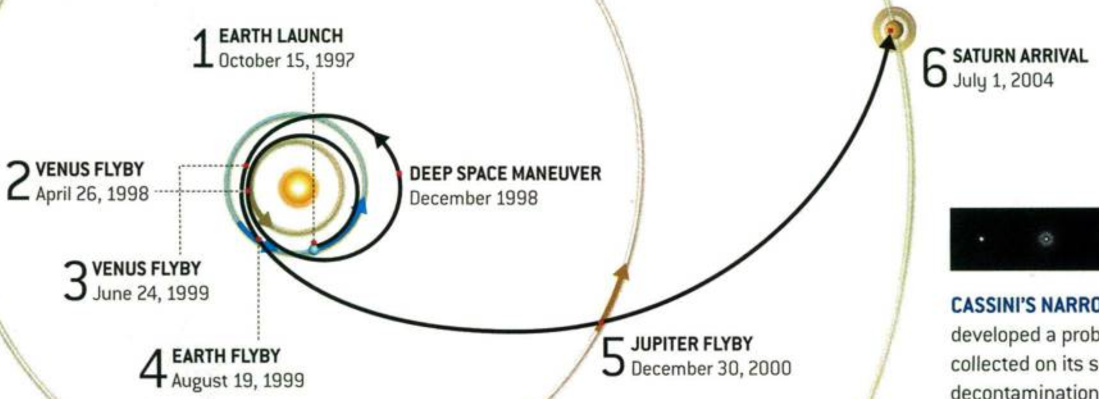
CASSINI LIFTS OFF from Cape Canaveral in October 1997. This time exposure captures the Titan/Centaur rocket and its plume of fire from off the Atlantic coast. NASA



IO STANDS IN FRONT OF JUPITER as its shadow falls on the cloudtops in this Cassini image from late 2000. The spacecraft was then nearly 12 million miles from Jupiter. NASA/JPL



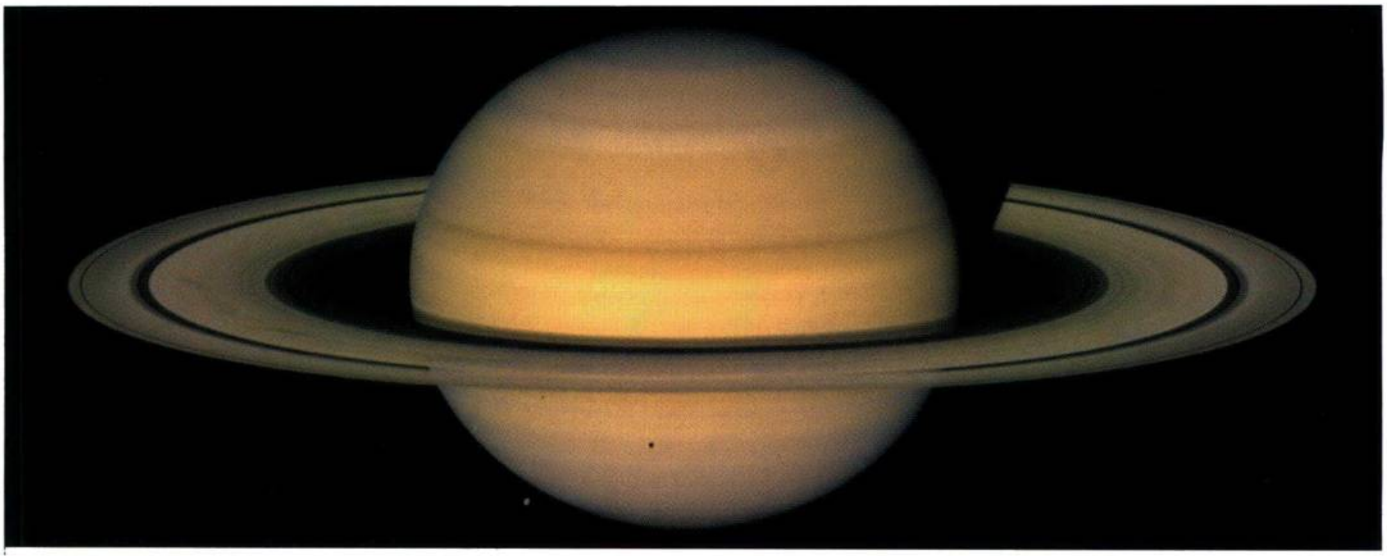
CASSINI TOOK ITS FIRST SATURN IMAGE in October 2002, when the spacecraft was still 175 million miles from the planet. Titan stands above the planet. NASA/JPL



1 EARTH LAUNCH
October 15, 1997
2 VENUS FLYBY
April 26, 1998
DEEP SPACE MANEUVER
December 1998
3 VENUS FLYBY
June 24, 1999
4 EARTH FLYBY
August 19, 1999
5 JUPITER FLYBY
December 30, 2000
6 SATURN ARRIVAL
July 1, 2004

CASSINI'S LONG AND WINDING ROAD to Saturn began with an October 1997 launch and included gravity assists from Venus (twice), Earth, and Jupiter. *ASTRONOMY*: ROEN KELLY

CASSINI'S NARROW-ANGLE CAMERA developed a problem when haze collected on its surface during a decontamination run. This time sequence (left to right) shows an out-of-focus star image from May 2001 (second image). Further treatments corrected the problem. NASA/JPL



VOYAGER 2 flew past Saturn in 1981. With a mission lasting years instead of days, Cassini promises a flood of information compared to Voyager. NASA/JPL

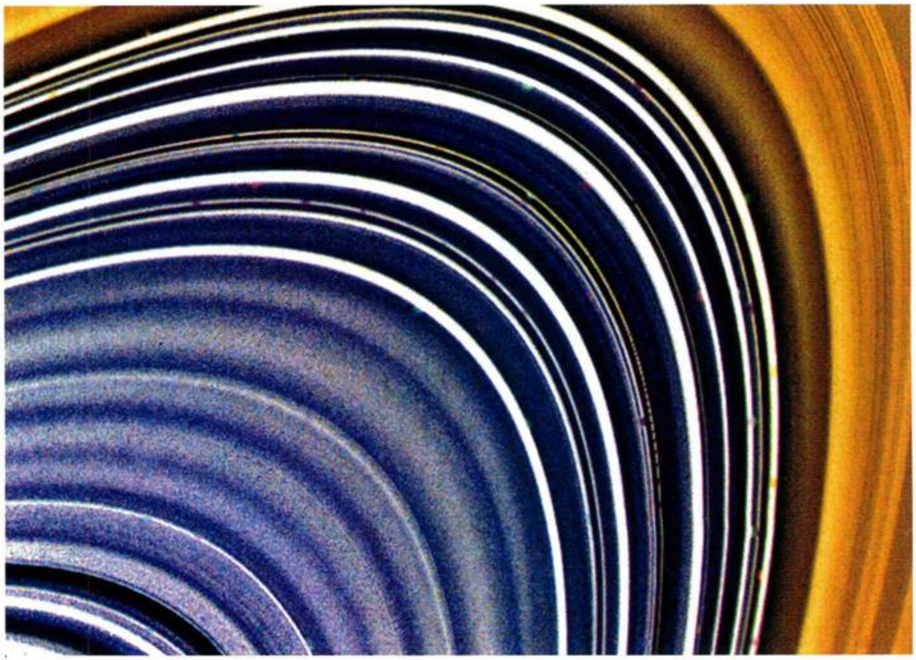
Earth-based radar observations indicate much of Titan's surface is very smooth — suggesting liquid or frozen lakes.

Titan's surface may prove especially interesting, with landscapes shaped by hydrocarbon rain and rivers, and lakes with shorelines carved by tides. Titan's environment is in some ways analogous to that of a very early Earth, before life evolved, and it could provide clues to help us understand "prebiotic" chemical processes. Also, images from the Hubble Space Telescope reveal broad regions of high reflectivity and others of very low reflectivity, so Titan's surface might have some similarity to Iapetus (see below).

Understanding Titan's surface ranks among the highest priorities for the Cassini/Huygens mission. Huygens will descend below the haze and even below possible tropospheric clouds before landing on the surface. It will get a good view, but the probe will see only a small patch of ground. Scientists expect RADAR, a Cassini experiment that includes a synthetic aperture radar imager, an altimeter, and a radiometer, to map about 20 percent of the surface at a resolution better than 0.6 mile (1 kilometer). In the case of the ISS cameras, however, at first no one thought they would be able to image Titan's surface through the smoggy atmosphere. But that was before ground-based and Hubble observations demonstrated the existence of spectral "windows."

ISS actually has better infrared filters for imaging Titan's surface than Hubble does. Still, a major uncertainty remains. If Titan's atmosphere doesn't look clear (or mostly so) at the infrared wavelengths reflected from the surface, then the best possible resolution ISS can achieve may be about 60 miles (100 km). This is roughly equal to Hubble's resolution, and it won't matter how close Cassini gets to Titan. Models of Titan's haze indicate sufficient light passes through the atmosphere, leading many scientists to expect sharp images — but models can be wrong.

Thus, the ISS camera may photograph most of Titan's surface at better than 1-km resolution, with selected areas imaged at 50-meter resolution or even better — or it may do only a little better than Hubble. Because my main job on Cassini is to plan and analyze ISS images of Titan's surface, I await the first close images (to be taken in early July 2004) with high anxiety.



THE RINGS OF SATURN have fascinated observers for centuries. Voyager showed that the rings consist of thousands of ringlets; Cassini will probe their structure in far greater detail. NASA/JPL

TOP 10 MISSION HIGHLIGHTS

The combination of Cassini and Huygens promises to send a tidal wave of information back to Earth for at least the next four years. Here are the top ten highlights of the mission presented in chronological order.

1 Saturn approach movies (January–June 2004)

The imaging experiments will take movies of the entire saturnian system. These will show the atmospheric circulation of Saturn, the spectacular and dynamic system of rings, the orbiting satellites (31 are known currently), and the giant magnetosphere. Cassini doesn't see at just visible wavelengths, but also at much shorter (ultraviolet) and longer (infrared and radio) wavelengths. By April, ISS images will be sharper than those taken with Hubble. We may discover new satellites or better understand the interactions between the rings and the small inner satellites.

2 Phoebe flyby (June 11, 2004)

Phoebe is the outermost of Saturn's medium-size moons, and Cassini will pass it three weeks before reaching Saturn. The moon's inclined, retrograde, and chaotic orbit tells us that Saturn captured this 135-mile-diameter (220 km) object, most likely an asteroid or an extinct comet. Cassini will pass within 1,200 miles (2,000 km), close enough to measure the moon's mass and density, return images with resolutions up to 65 feet (20m) per pixel, and determine the composition of its organic-rich surface. Past spacecraft observations of small bodies have yielded big surprises, so now we expect the unexpected.

3 Saturn orbit insertion (July 1, 2004)

After the Phoebe flyby, a "quiet period" commences with observations taken only by instruments that detect magnetic fields and analyze particles. The quiet ends with the main engine firing, or "SOI burn." If this critical event fails — and the spacecraft's redundant engine, designed to turn on automatically if something goes wrong with the primary engine, also fails — the rest of the mission will be lost. Switching to the backup engine would eliminate all the science at closest approach, but it would save the rest of the mission.

After the burn, the spacecraft is programmed to turn to Earth briefly to let us know if all went well. Assuming that it did, Cassini then will begin a unique sequence that includes the closest observations of Saturn and the rings, and measurements of the fields and particles near Saturn. To enable these science observations, the SOI burn actually starts earlier than its optimal time (when Cassini lies closest to Saturn) and instead *ends* when the spacecraft is closest to Saturn.

The mass spectrometer will eject its protective cover and swallow particles to determine their compositions and other properties. These particles will include material from the diffuse E ring, which may originate from the moon Enceladus. Radio waves sent from the spacecraft to Earth will pass through the rings, recording their structure in great detail. Cassini flies through the ring plane twice, before and after the SOI burn, both times through a gap between the F and G rings. Ring modelers tell us this should be safe — we hope they're right.

After all the excitement on July 1, everyone involved with the mission will deserve a good rest. Some of us won't be ready to sleep quite yet, however. Cassini flies within about 190,000 miles (300,000 km) of Titan on July 2. The best images will have a resolution of 1.2 miles (2 km) per pixel, about fifty times better than images from Hubble. We may learn more about Titan from this one opportunity than we learned from Voyager 1.

This flyby will be especially important for checking models of winds on Titan, which could be critical to the success of the Huygens probe. It also gives us our best look at the south polar region. Planetary scientists remain uncertain about the optical properties of Titan's lower atmosphere, and we do not know how well ISS can image the surface. This flyby should tell us whether the ISS images will be dramatically sharper than those from Hubble, or whether we'll have to rely on the RADAR experiment to map the surface.

4 Titan makes a splash
(October 26, 2004–January 14, 2005)

Three close flybys of Titan are planned for early in the mission: October 26, 2004 (Titan-A), December 13, 2004 (Titan-B), and January 14, 2005 (Titan-C and the Huygens probe entry). Cassini will pass just 750 miles (1,200 km) from Titan's surface during the Titan-A flyby. The spacecraft will fly through the tenuous top of Titan's extended atmosphere, and this is when we find out just how rarified it really is. If it's thicker than models predict, we may not be able to pass much closer and will need to change the many subsequent flybys planned at just 590 miles (950 km). If it is thinner than predicted, then 590 miles may be too high to accomplish some science objectives. (This mission provides plenty of opportunities for modelers to become either heroes or goats!)

Titan-A also will provide the first close look at Titan by many of Cassini's instruments, including the Visible and Infrared Mapping Spectrometer, which will map the moon's surface composition, and the RADAR experiment. Titan-B passes a bit farther away, which should prove better for ISS and some other experiments because the spacecraft can be controlled by its reaction wheels rather than its thrusters. The reaction wheels provide better pointing stability, so we should get sharper images. ISS will image a large region of the surface during Titan-A and then zoom in on particular regions during Titan-B. We picked arbitrary spots to zoom in on because we don't yet have any idea what features exist on Titan. The imaging team had hoped to target interesting spots after seeing the region at lower resolution during Titan-A, but mission controllers tell us there won't be enough time to make any changes. Maybe they'll find a way if we discover active volcanoes or rivers of organic liquids and then show the planned high-resolution images just miss these features.

On December 24, 2004, Cassini is scheduled to release the Huygens probe into a trajectory toward Titan. Cassini will then fire its engines briefly to pass 37,000 miles (60,000 km) from the moon. If a problem crops up before the release, mission planners could decide to hold the probe until a new Titan-D flyby could be planned. However, this decision would force a change in Cassini's tour during the following months, eliminating the first two close encounters with Enceladus. Huygens should enter Titan's atmosphere on January 14, 2005. For details on its mission, see "Probing Titan" on page 40.

5 Enceladus encounters
(February 17 and March 9, 2005)

If the Huygens probe is released on Christmas Eve, Cassini will pass by the moon Enceladus on February 17 (at an altitude of 733 miles [1,179 km]) and on March 9 (at just 310 miles [499 km] above the surface). The bright surface of Enceladus shows evidence for internal activity that has eliminated most of the impact craters that must have formed early in its history. Voyager images showed grooved terrain that may be similar to that on Ganymede, Europa, or Triton. Enceladus's surface reflects nearly 100 percent of the incident sunlight, which suggests the moon is covered with a fresh layer of frost.

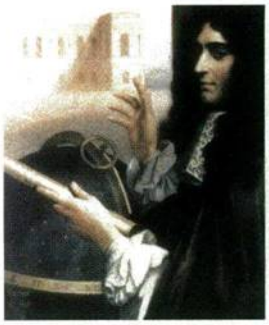
Enceladus also seems to be the source of Saturn's E ring, a tenuous ring of particles that extends from the orbit of Enceladus out past the orbit of Dione. Perhaps the particles originate in active venting from

/// WHAT'S IN A NAME?

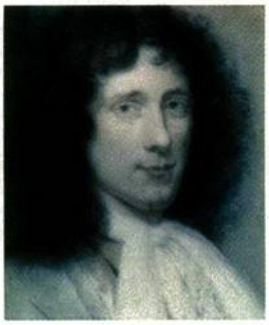
Famous in their own time, a pair of 17th-century European icons stake a renewed claim to fame with the impending arrival at Saturn of the Cassini spacecraft and Huygens probe.

NASA chose to name its Saturn orbiter after Italian-French astronomer Giovanni Cassini. Between 1671 and 1684, Cassini discovered four of Saturn's medium-size moons: Dione, Iapetus, Rhea, and Tethys. He also spotted several ring features, including the well-known Cassini Division that separates the outer A ring from the brighter B ring. In addition, Cassini was the first scientist to measure the scale of the solar system.

The European Space Agency decided to name its probe of Titan after Dutch astronomer Christiaan Huygens. The choice couldn't be more appropriate because this amateur astronomer discovered Titan in 1655. Huygens was also the first person to understand that Saturn's strange, elongated appearance in the telescopes of the time was the result of a thin ring of orbiting particles that nowhere touched the planet.



GIOVANNI CASSINI discovered four of Saturn's major moons and the widest gap in its rings. NASA/JPL



CHRISTIAAN HUYGENS discovered Titan and identified the true nature of Saturn's rings. NASA/JPL the moon's surface or some other process; Cassini should solve this mystery. Magnetic experiments on the spacecraft also may find evidence for salty water in the moon's interior. Just 310 miles (500 km) in diameter, Enceladus has only one plausible source of the energy necessary for any geological activity: tidal heating. This process causes active volcanism on Jupiter's moon Io. Because of the interest in Enceladus, a total of four close flybys are planned.

6 Saturn/ring occultations (April–September 2005)

After the second Enceladus flyby, mission controllers will increase Cassini's orbital inclination from Saturn's equatorial plane to about 22°. This positions the spacecraft for a series of Saturn and ring occultations of both Earth (for the radio science experiment) and the Sun (for optical sensors). These measurements will profile the ring structure and physical properties of the ring particles and Saturn's atmosphere.

7 Inner satellite encounters (September–November 2005)

Cassini's orbital inclination will be reduced to set up a series of close flybys of the moons Dione, Rhea, and Hyperion, and a more distant one of Tethys. Tethys, Dione, and Rhea are medium-size moons (from 660 miles [1,060 km] to 950 miles [1,530 km] across) composed mainly of water ice. They are heavily cratered over most of their surfaces, although enigmatic "wispy" terrain exists on the trailing hemispheres of Dione and Rhea, and Tethys has a huge rift called Ithaca Chasma. Hyperion has an irregular shape, like a squashed potato. It also has an almost chaotic orbit, perhaps resulting from a recent collision.

The cratering record of all Saturn's moons suggests two main sources of impacting bodies: those in orbit around the Sun (probably comets) and those in orbit around Saturn (perhaps remnants from the catastrophic disruption of a moon like Hyperion). The saturnian system has a history of catastrophic impacts and re-accretion of moons, of which the current rings may be the remains.

8 Mapping and monitoring phase (July 2006–July 2007)

The icy satellite encounters will be followed by several Titan flybys that serve to rotate Cassini's orbit. The goal is to get the space-

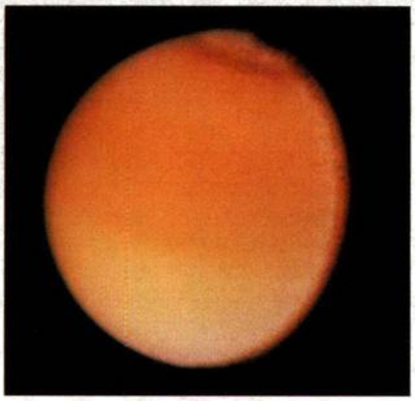
/// PROBING TITAN

Tucked inside the Cassini orbiter is a small spacecraft named Huygens that will unveil mysterious Titan, the second largest moon in the solar system, whose surface is shrouded beneath a hazy atmosphere thicker than Earth's. This traveling laboratory carries six science experiments designed to study the clouds, atmosphere, and surface of Titan.

The probe currently is scheduled to reach Titan on January 14, 2005, some three weeks after being released from its berth inside Cassini. Its target: a landing site at approximately 11° south latitude and 163° east longitude. The six experiments will be turned on in a preprogrammed sequence after the heat shield has been released. The sequence is controlled by timers, acceleration sensors, altimeters, and a Sun sensor.

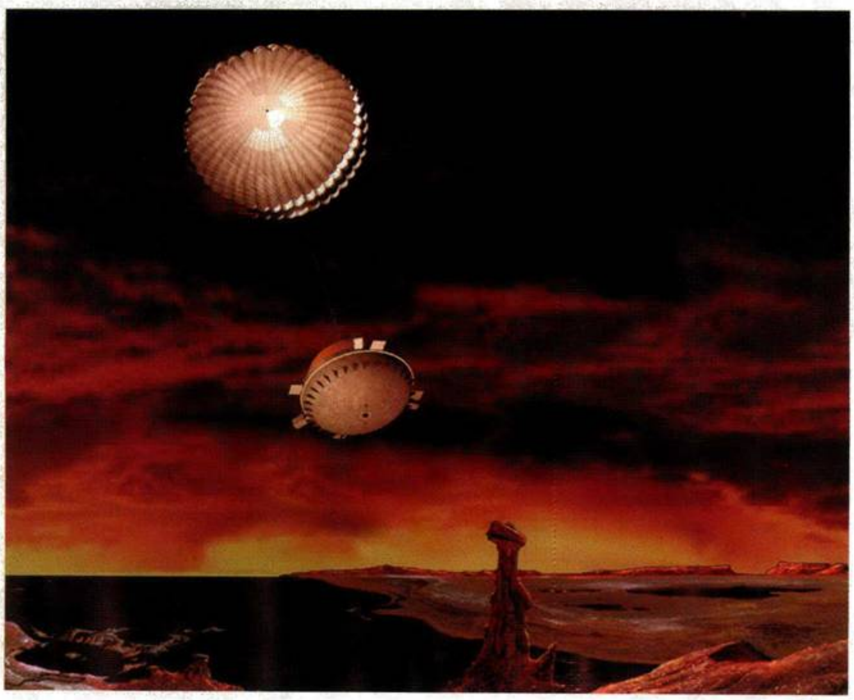
Measurements of the atmosphere's temperature, pressure, and density, as well as wind direction and speed will be taken during descent. The probe can detect electromagnetic signals like those emitted by lightning. Its radar altimeter will study the topography, roughness, and electrical properties of Titan's surface. Another experiment will capture and analyze atmospheric gases and particles to determine the compositions of complex organic materials.

Huygens's cameras will take images and spectra of the surface and atmosphere during the descent, and a bright lamp will be turned on shortly before landing to determine the reflectivity and composition of the surface. The probe's rotation will allow scientists to produce a mosaic of surface images.



SHROUDED TITAN, whose surface lies hidden beneath a thick layer of haze, will be a high priority for Cassini. Some scientists think the spacecraft's camera will penetrate the haze to reveal significant detail on the surface. NASA/JPL

If the probe remains functional after the landing, it will directly measure the physical properties and composition of the surface. If the surface is liquid, then an acoustic sounder will measure its depth; its density can be determined by how high the probe floats. All this precious information will be collected and sent back to the Cassini orbiter over a period of just three hours. If anything goes wrong, there won't be a second chance.



HUYGENS PARACHUTES TO TITAN'S SURFACE, where it may find lakes or oceans of hydrocarbons. In this artist's conception, the surface glows dimly as sunlight barely penetrates Titan's thick atmosphere, which Huygens will reveal in unprecedented detail. NASA/JPL

Saturn, its rings, and haze-covered Titan have deservedly received most of the pre-arrival attention from planetary scientists and the public. But Cassini will subject most of Saturn's medium-size moons to intense scrutiny as well. Mission planners have not finalized the orbital tour yet. One scenario being considered includes 69 orbits of Saturn over the four-year mission. About 40 of those orbits include close flybys of Titan, both for scientific purposes and to modify the spacecraft's orbit, while most of the rest target the cornucopia of other intriguing moons shown below.

THE BIG CRATER on Mimas, which helped earn the moon its "Death Star" nickname, formed from an impact that came close to shattering the entire moon. NASA/JPL IMAGES

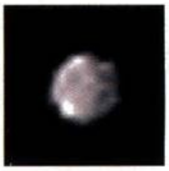
ENCELADUS shows signs of tidal heating, as evidenced by a relatively fresh surface that in some regions has been wiped clear of impact craters.

BRIGHT REGIONS dense with craters stand next to dark, lightly cratered plains on Tethys. Part of a huge canyon system can be seen along the right edge.

WISPY TERRAIN of unknown origin dominates the trailing hemisphere of Dione (right), while countless impact craters pock the more typical leading hemisphere.

ANCIENT RHEA'S surface dates back 4.5 billion years to the birth of the solar system. Yet other regions of the big moon show signs of more recent activity.

IAPETUS has one side darker than coal and the other brighter than freshly fallen snow. It will be a target for Cassini during a leisurely encounter late in the mission.



DISTANT PHOEBE was not seen up close by the Voyager spacecraft. Cassini will pass within 1,200 miles of the surface three weeks before it reaches Saturn.

craft so its farthest point from Saturn lies out in the magnetotail, the region where the solar wind stretches Saturn's magnetosphere far from the planet. The series of 17 Titan flybys, most at an altitude of 590 miles (950 km), also increases Cassini's orbital inclination and offers a better view of the rings. The close Titan flybys enable RADAR mapping of the surface and other science objectives. The year from July 2006 to July 2007 may lack the drama of earlier mission phases, but it will enable systematic monitoring and mapping of Saturn, its rings, its magnetosphere, and Titan.

9 Saturn movies and Iapetus (July–September 2007)

The most distant part of Cassini's orbit will be rotated toward the Sun to allow observations of Saturn's atmosphere at both great distance and low phase angle (the Sun-Saturn-Cassini angle). Scientists usually have a strong desire to get closer to the target of interest, not farther away. But the narrow-angle camera has unique spectral capabilities, and Cassini needs to be far enough away to fit all of giant Saturn into a single image or into a mosaic of four images. Cassini also needs plenty of time to monitor Saturn's weather. We will acquire the best movies of atmospheric dynamics on Saturn near the outer boundaries of these orbits.

While Cassini is out there, it will come within 620 miles (1,000 km) of Iapetus on September 10, 2007. Iapetus ranks among the strangest of all moons — black (or very dark red) on one side and nearly white (reflecting 50 percent of incoming light) on the other. Scientists debate whether the black, organic-rich material oozed out of the subsurface or was plastered on from some external source, perhaps Phoebe. This should be a fascinating encounter. The spacecraft's orbital velocity will be slower in the outer part of its orbit, so scientists will have more time to collect and return data while near Iapetus. Iapetus is the solar system's only medium-size moon (890 miles [1,440 km] across) in a highly inclined orbit. It also has a low density, which suggests it contains lots of methane or ammonia.

10 Crank it up: extreme inclinations (October 2007–July 2008)

A series of ten passes by Titan will be used to increase the orbital inclination as high as possible for observations of Saturn's rings, measurements of magnetic fields and particles well above Saturn's orbital plane, and monitoring Saturn's poles to observe phenomena such as aurorae. The last five orbits of the planned mission have an inclination of 75.6°, looking almost straight down onto the rings and poles. The closest encounter with a "rock" occurs here: Epimetheus, seen from a distance of 3,850 miles (6,190 km) on December 3, 2007. There's also another close pass of Enceladus on March 12, 2008, as Cassini passes within 620 miles (995 km) of it.

EXTENDED MISSION

If Cassini makes it to the end of its planned mission, it should have fuel and power for an extended mission of a year or more. Where should Cassini go? It would need to keep making close passes by Titan because the large moon's gravity is the only way to change the spacecraft's orbit significantly. That would be fine with mission scientists because Titan is a complex world and there will be plenty of unmapped regions and poorly observed phenomena. A year at Saturn lasts 16 Earth years, so an extended mission would enable observations of new seasons and atmospheric changes on Titan, if any. Otherwise, Cassini can follow up on the exciting discoveries we anticipate elsewhere in the saturnian system.

Extended missions offer great opportunities because "success" has already been declared — so there is less aversion to risk. Perhaps scientists will direct Cassini to pass even closer to the rings or to Titan's surface. Some of the most significant results from the Galileo mission to Jupiter came from its extended missions, including the best observations of Io and Europa. We all hope Cassini proves even more successful. ■

To learn more about the Cassini mission, visit www.astronomy.com/toc

{ EXTRAGALACTIC ASTRONOMY }

In the line of fire

Astronomers are closing in on the universe's most powerful explosions: gamma-ray bursts. They are beams of matter and energy, and many are aimed straight at Earth. /// BY STEVE NADIS

SINCE THEIR DISCOVERY SOME thirty years ago by military satellites monitoring nuclear explosions, gamma-ray bursts (GRBs) have endured as one of astronomy's greatest mysteries. They appear at seemingly random spots in the sky several times a day, unleashing — between a fraction of a second and about a minute — prodigious blasts of energy that, by some accounts, rival the Big Bang itself. The origins of these bursts have stumped researchers for decades, but the picture is now coming into sharper focus. Scientists have found that the burst energy is not sprayed in all directions but instead is channeled into narrow, cone-shaped beams or jets. Most of these jets pass by unseen, but occasionally one is pointed right at us, as if we were sitting at the end of a gun barrel. Far from feeling uneasy, gamma-ray astronomers live for the chance to be shot through with high-energy photons.

Awareness of the beamed nature of GRBs has enabled investigators to estimate, in one fell swoop, both the energy of individual bursts and their frequency. "If you didn't know the geometry, and assumed spherical emission when it's really conical, you could infer an energy release a thousand times bigger than it really is," notes Shri Kulkarni of the California Institute of Technology. "And if the beams are as narrow as we think they are, for every GRB I see there are a thousand I don't see."

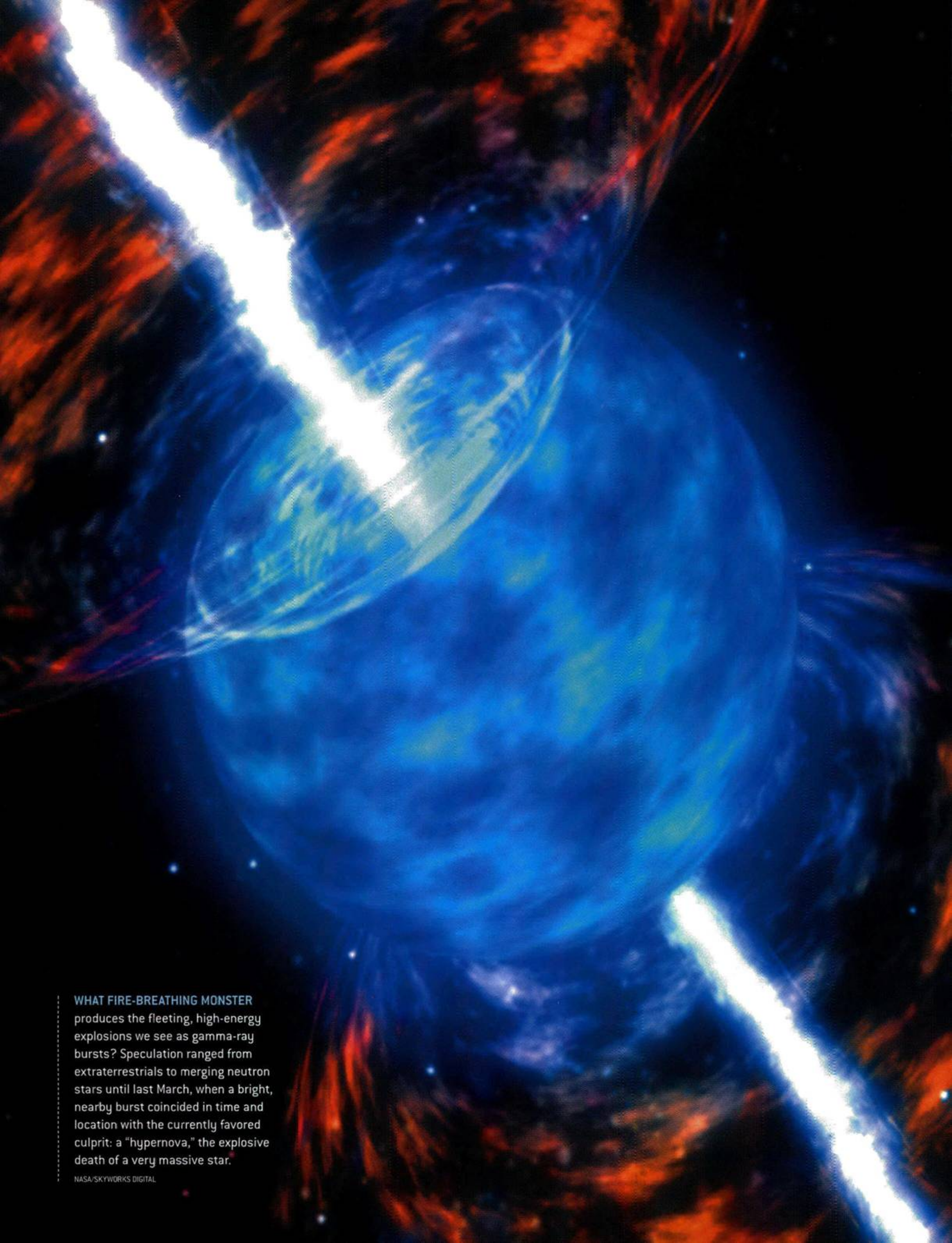
One of the most telling clues about the origin of GRBs was uncovered on March 29, 2003, when NASA's High Energy and Transient Explorer (HETE-2) satellite detected a burst from the constellation Leo. The burst's subsequent "afterglow" revealed the GRB arose just 2.6 billion light-years away and was associated with a bright supernova that occurred around the same time. Now theorists believe they're converging on a plausible explanation for GRBs, linking the most common class of bursts (those typically lasting about twenty seconds) to the creation of black holes when massive stars (originally about 30 or more times the mass of the Sun) collapse and die in a blaze of supernova glory.

The suggestion that gamma rays are shot through space from a two-way cosmic cannon has been around for at least a decade, and nature holds other examples of jetted flows from stars and active galactic nuclei. But it is difficult to determine if the gamma-ray pulses periodically detected by our orbiting instruments are beamed in jets or radiated in all directions.

This problem is compounded by special relativity. In the standard "fireball" model, gamma rays are thought to be produced from the extreme heat generated by internal collisions within a torrent of material ejected from a dying star at close to the speed of light. If photons are emitted from a hot, high-velocity source, they don't wander all over the place but instead are concentrated in discrete, laser-like beams, traveling perpendicular to the surface. The faster the surface expands, the narrower the beam. One consequence of relativity, Kulkarni explains, is that "very fast-moving surfaces do not reveal themselves fully. You see only a small portion. And if you see only a little bit, you can't tell if it's an entire sphere or a small section of a sphere like a cone."

The first afterglow

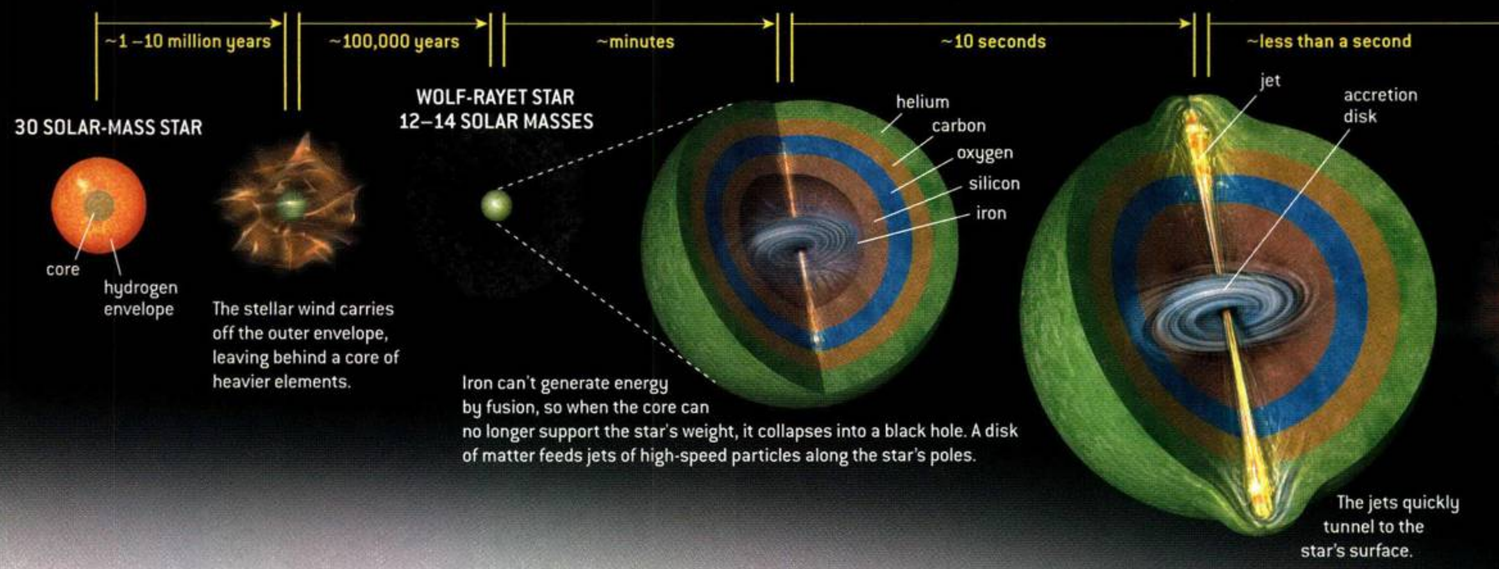
The model sharpened dramatically in 1997 with the discovery of GRB afterglows — X-ray, optical, and radio emissions that persist for weeks and months after bursts. Afterglows, according to the fireball model, are produced when jets bump into the interstellar media and other matter spewed out by the star. Due to these collisions, jets slow down steadily during the afterglow phase. When the speed dips



WHAT FIRE-BREATHING MONSTER produces the fleeting, high-energy explosions we see as gamma-ray bursts? Speculation ranged from extraterrestrials to merging neutron stars until last March, when a bright, nearby burst coincided in time and location with the currently favored culprit: a "hypernova," the explosive death of a very massive star.

NASA/SKYWORKS DIGITAL

THE COLLAPSAR MODEL OF A GAMMA-RAY BURST



The stellar wind carries off the outer envelope, leaving behind a core of heavier elements.

Iron can't generate energy by fusion, so when the core can no longer support the star's weight, it collapses into a black hole. A disk of matter feeds jets of high-speed particles along the star's poles.

The jets quickly tunnel to the star's surface.

ASTRONOMY: ROEN KELLY

below a critical value, it becomes possible to see the jet's "edge" — proof that the emission is not spherical because spheres, by definition, have no edges.

In 1997, James Rhoads, an astronomer at the Space Telescope Science Institute, encapsulated these ideas in a simple diagnostic test called the "jet break." After running into surrounding material, Rhoads said, a jet will lose speed and start to expand sideways. When this happens, the luminosity of the afterglow falls off sharply as light focused into a narrow cone becomes more diluted. This should appear as a change in the slope of the "light curve" — a graph of luminosity versus time — at the precise point where brightness begins to decline more abruptly.

In a 1999 study, Re'em Sari of the California Institute of Technology and his colleagues found indications of "jet-like behavior" in three previously observed GRBs. Luminosity was dropping so quickly in those cases that they concluded the afterglow observations must have begun after the jet break.

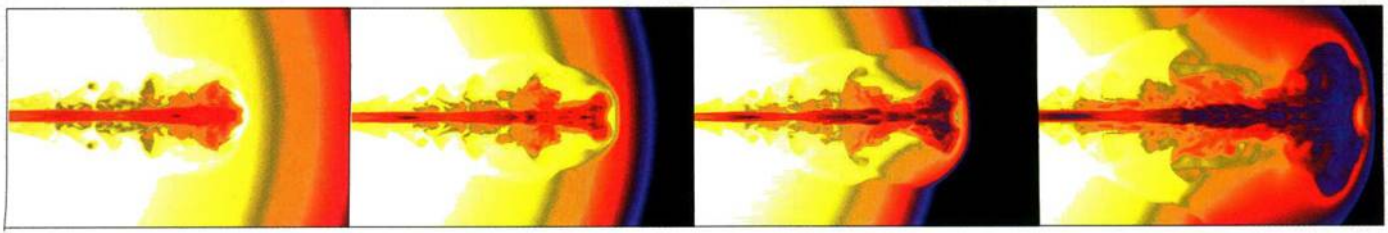
But a broader analysis of a larger observational sample was needed to draw more meaningful comparisons between bursts. This came recently when Dale Frail of the National Radio Observatory, Kulkarni, Sari, and eleven other astronomers examined the light curves of seventeen GRB afterglows in a variety of wavelengths. After confirming the gamma-ray energy was focused in jets, the team went on to calculate the angular size of those jets based on the time of the jet break: The later the break occurred after the burst, the bigger the "opening angle" of the cone. Most jets, they concluded, were just a few degrees wide. An independent analysis by Alin-Daniel Panaitescu of Princeton and Pawan Kumar of the University of Texas reached similar conclusions.

Clocking GRB energies

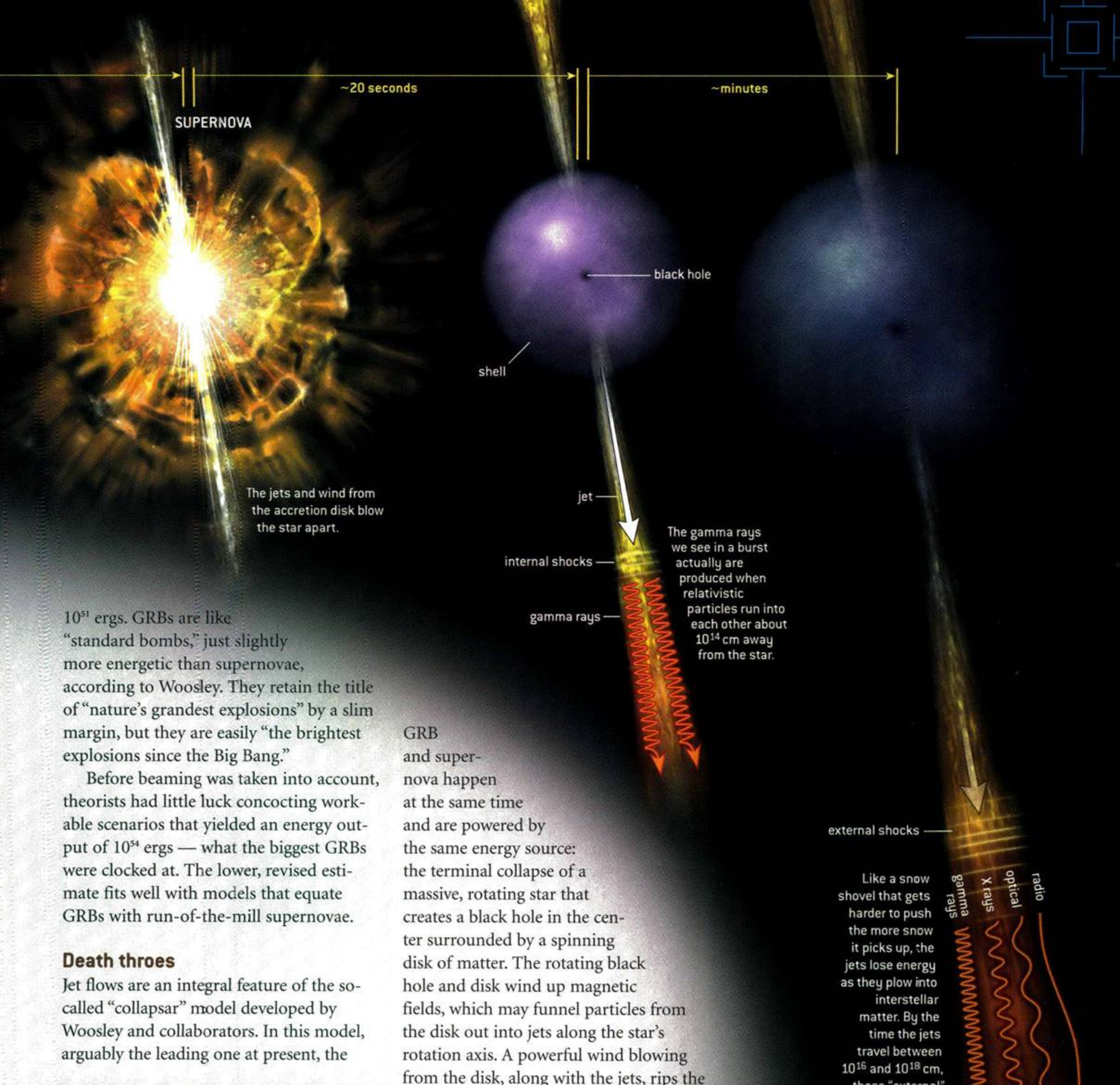
Knowledge of beaming angles is important because scientists now think different angles account for different luminosities observed in gamma-ray bursts, with tightly focused jets appearing brighter than those that are more widely dispersed. "Early on, people didn't realize how small the beams are," says Stan Woosley, a theorist at the University of California, Santa Cruz. "They assumed angles of about twenty degrees, but now it looks closer to four degrees."

Narrow beams mean that for every GRB we observe, there are 500 to 1,000 bursts invisible to us because they're pointing in another direction. Statistically, the data suggest that at least 1,500 GRBs occur in the visible universe each day, which is equivalent to a birthrate of one stellar-mass-size black hole each minute. This figure seems reasonable enough to Woosley as it means just "one percent of the stars massive enough to die as supernovae end up as GRBs."

Angular calculations also permit estimates of the total gamma-ray energy release, which appears to be fairly constant from one burst to the next: roughly



JETS OF RELATIVISTIC PARTICLES destined to become a gamma-ray burst force their way out of a massive star in this computer simulation. According to the leading theory, when a very massive, dying star can no longer support its own weight by nuclear fusion, its core collapses into a black hole surrounded by a spinning disk of material. Magnetic fields may accelerate the particles in this disk to near-light speeds along the star's rotational axis. These jets tunnel through the star in about ten seconds, and along with a powerful wind of particles from the accretion disk, they destroy the star in a hypernova. If the jets are aimed within about 5 degrees of Earth, observers will see the highest energy particles (yellow and orange) shine as a gamma-ray burst that lasts for as long as it takes for the black hole to consume the star's inner core, about 20 seconds. WEIQUN ZHANG AND STAN WOOSLEY



The jets and wind from the accretion disk blow the star apart.

The gamma rays we see in a burst actually are produced when relativistic particles run into each other about 10^{14} cm away from the star.

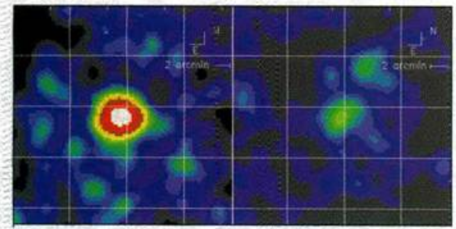
Like a snow shovel that gets harder to push the more snow it picks up, the jets lose energy as they plow into interstellar matter. By the time the jets travel between 10^{16} and 10^{18} cm, these "external" shocks produce lower energy (X-ray, optical, or radio) afterglows that can last from minutes to months.

10^{51} ergs. GRBs are like "standard bombs," just slightly more energetic than supernovae, according to Woosley. They retain the title of "nature's grandest explosions" by a slim margin, but they are easily "the brightest explosions since the Big Bang."

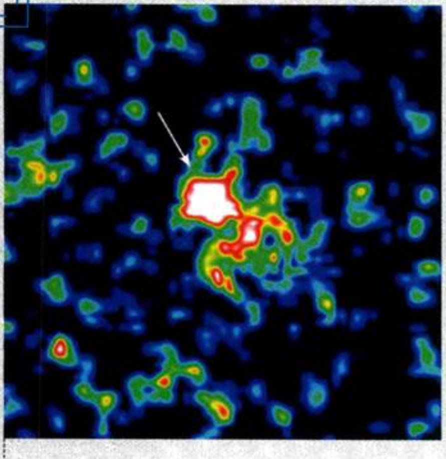
Before beaming was taken into account, theorists had little luck concocting workable scenarios that yielded an energy output of 10^{54} ergs — what the biggest GRBs were clocked at. The lower, revised estimate fits well with models that equate GRBs with run-of-the-mill supernovae.

Death throes

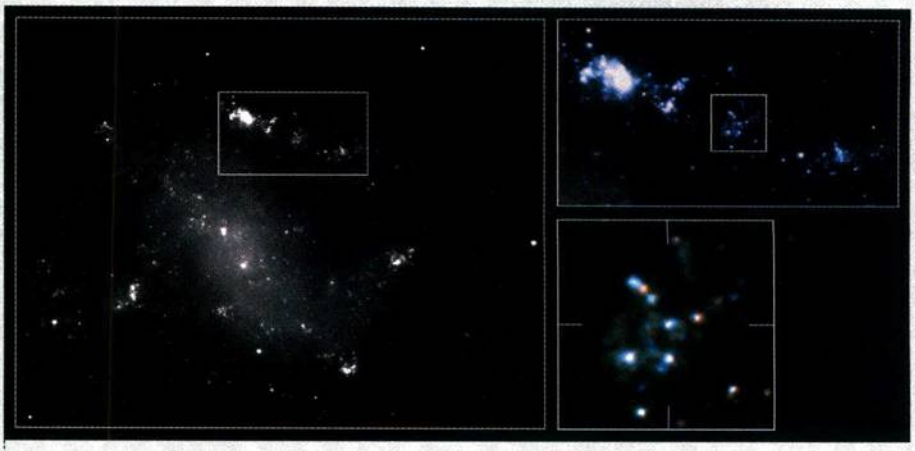
Jet flows are an integral feature of the so-called "collapsar" model developed by Woosley and collaborators. In this model, arguably the leading one at present, the GRB and supernova happen at the same time and are powered by the same energy source: the terminal collapse of a massive, rotating star that creates a black hole in the center surrounded by a spinning disk of matter. The rotating black hole and disk wind up magnetic fields, which may funnel particles from the disk out into jets along the star's rotation axis. A powerful wind blowing from the disk, along with the jets, rips the star apart. The relativistic jets that shoot out in opposite directions give rise to gamma-ray emissions. The rest of the star's outer shell expands at a more modest pace because the same amount of energy is imparted to a greater bulk of matter; as a result, it moves more slowly. Although GRBs and supernovae traditionally are considered separate phenomena, in this model, they're different manifestations of the same explosion (at least some of the time — perhaps one percent of supernovae are involved with GRBs, while 99 percent



THE FIRST X-RAY AFTERGLOW (left) was detected by the satellite BeppoSAX eight hours after a GRB was observed from the same location on February 28, 1997, and again after three days (right). Afterglows help pin down GRB distances and host galaxies. ENRICO COSTA AND BEPPOSAX TEAM



THE FIRST OPTICAL AFTERGLOW also came from the GRB of February 28, 1997. In this Hubble image, the arrow points to the afterglow (white). The three-pronged object nearby may be the host galaxy. K. SAHU, M. LIVIO, L. PETRO, D. MACCHETTO, STScI, AND NASA



THE GRB–SUPERNOVA CONNECTION gained support in 1998, when a bright supernova appeared where a faint GRB had been spotted hours earlier. These Hubble pictures, taken two years after the burst, are the first high-resolution images of a GRB host galaxy. The burst, dubbed GRB 980425, and the supernova, called 1998bw, occurred in a star-forming region in one arm of barred spiral galaxy ESO 184-G82. S. HOLLAND, J. HJORTH, J. FYNBO, B. THOMSEN, M. ANDERSEN, G. BJÖRNSSON, A. JAUNSEN, P. NATARAJAN, AND N. TANVIR/ESA

are thought to be powered by neutron star formation or neutrinos).

Additional support for the link between GRBs and supernovae comes from observations that show bursts tend to originate in star-forming regions. "In places where lots of stars are born, a lot of massive stars will also be dying," notes theorist Tsvi Piran of Hebrew University in Israel. Andrew Fruchter, an astronomer at the Space Telescope Science Institute, agrees. "The hosts show signs of being unusually star-forming: They are blue and have strong emission lines," he says. "They also show disturbed morphologies." Other suggestive evidence comes from a study of the X-ray afterglow of a recent GRB using the XMM-Newton space telescope. James Reeves of the University of Leicester in England and his colleagues conducted a detailed spectral analysis of the afterglow that revealed the presence of light chemical elements — magnesium, silicon, sulfur, argon, and calcium — typically flung into space by a supernova explosion.

> Most of these jets pass by unseen, but occasionally one is pointed right at us, as if we were sitting at the end of a gun barrel.

With the various pieces of evidence combined, Woosley believes the case tying GRBs to star death is pretty compelling.

"We have a working model, and there's even some consensus in the community, but that doesn't make it right," he says. As an example, he points out that a dozen years ago, many people believed in the "thermonuclear" model, which assumed gamma rays were produced by rapid accretion of matter onto a neutron star, with magnetic confinement generating the requisite heat. Although the idea makes perfect sense, it is absolutely wrong, Woosley says. "I should know because it was my model."

Uncertainties afflict almost every aspect of the currently favored "collapsar" model. "Even if we know the GRB is caused by the explosion of a massive star, that still doesn't tell us *how* it blew up," Woosley says. On the most basic level, researchers can't describe how jets are made, nor what they are made of, although it is often assumed they consist of the universe's standard material, hydrogen, in the form of protons and electrons.

There are fundamental questions, as well, about the enigmatic source that accelerates jets to relativistic velocities and focuses the beams to such an exquisite degree. "What is the mysterious engine that produces so much energy yet can operate with such fine precision?" asks Kulkarni. "It's a rare combination of the delicate and the powerful." He is particularly intrigued by the collimation mechanism. "Making a cone of just one degree is like cutting a pizza into three hundred sixty slices. How does nature make these incredible pizzas?"

Kumar is mystified by the apparent "constancy of energy" among bursts, which he believes must be an important clue to what is behind the explosion. "Why isn't there a bigger variation in energy, and why are you only tapping about one percent of the total?" he asks. "It's as if you had $100,000 in a group bank account and everybody can only take out $1,000. There has to be a reason. Otherwise, people might take out $10, $100, or $10,000."

The GRB future is bright

Kumar also is trying to understand the properties of jets in a more precise way. "In our models, we think in terms of a cone carved out of a sphere, but things may not be as neat as a uniform cone," he says. "Different parts of the jets could be propagating at different speeds." He's now doing theoretical work to figure out what to look for when new data are available from SWIFT, NASA's orbiting GRB observatory, which is set to be launched in May.

With all the unanswered questions still swirling about bursts and jets, high hopes

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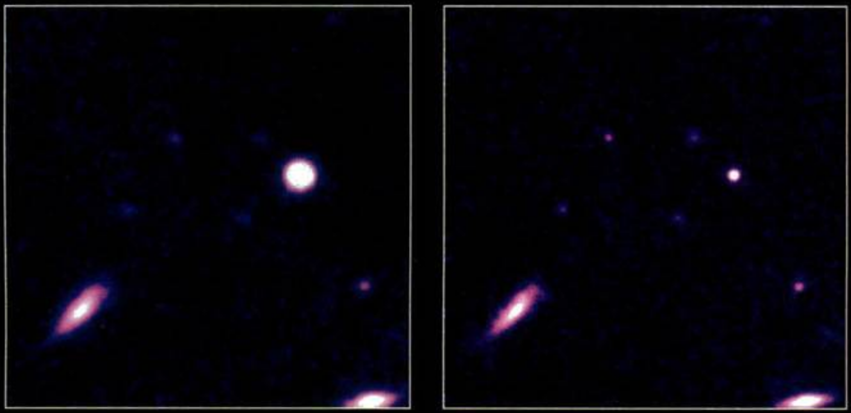
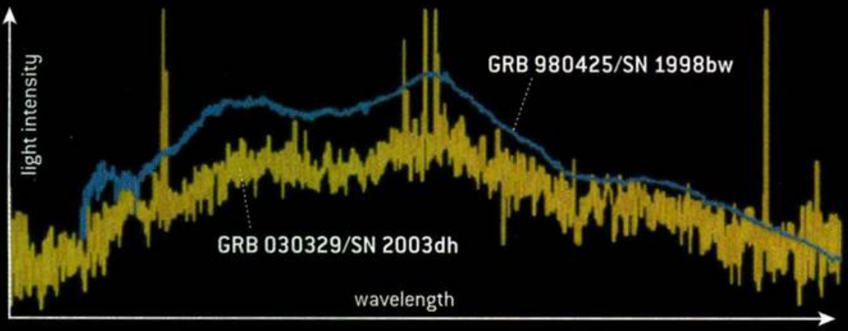
Steve Nadis *is a contributing editor and science writer in Cambridge, Massachusetts.*

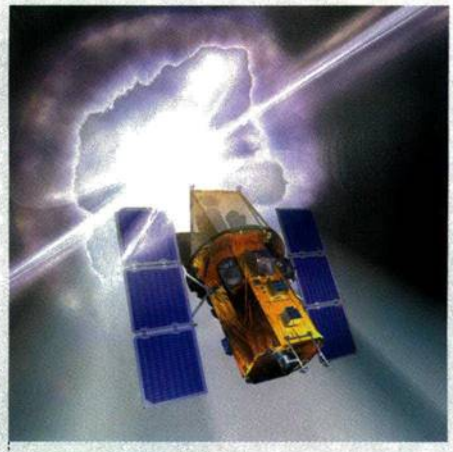
/// GRB 030329: THE SMOKING GUN FOR SUPERNOVA SOURCES



THE "ROSETTA STONE" of gamma-ray bursts was discovered on March 29, 2003, when the afterglow spectra of one of the brightest and closest GRBs ever detected showed the unmistakable earmarks of a supernova. The GRB was so powerful it briefly ionized Earth's upper atmosphere. Images from the Very Large Telescope in Chile show the optical afterglow fading after five days (left) and about a month (right). ESO



THE SAME UNDERLYING MECHANISM, if the shape of their spectra is any indication, appears to be responsible for the two GRBs most closely associated with supernovae: GRB 980425 and GRB 030329. Scientists think each arose from the core collapse of a massive star that gave rise to a supernova. The supernova light signature may not be visible until several weeks after the GRB (in the afterglow spectrum). That's because light may take this much time to escape the hot soup of particles and radiation created in the stellar explosion. P. MÉSZÁROS/*NATURE*



NASA'S SWIFT SATELLITE, expected to launch this May, will search for gamma-ray bursts and their X-ray and optical afterglows and "swiftly" beam the information to astronomers on Earth. SPECTRUM ASTRO

are being pinned on SWIFT. The mission is expected to spot about 300 GRB afterglows a year and monitor at least 1,000 afterglows in all, greatly expanding the number of bursts with known locations, which presently stands at about fifty. "We have a small sample right now and want to make sure it's representative of the entire class of GRBs," Kumar says.

"It's not only a matter of quantity, but quality," says Sari of SWIFT's potential contributions. "Burst positions will be given to people on Earth within seconds rather than hours, so we can look at the afterglows very quickly. That means we can catch jets with the smallest angles and earliest breaks."

Meanwhile, an independent strategy is being pursued, a strategy based on another test proposed by Rhoads in 1997. If GRBs truly are broadcast in discrete beams, then we should be able to see afterglows in some cases where it is impossible to see the bursts themselves. These "orphan afterglows," as Rhoads calls them, will be hard to find because they're much fainter and rarer than supernovae. "But they have to exist if this picture is right," he says.

Even without an orphan afterglow sighting, it appears that after thirty years of detective work, researchers finally are getting to the bottom of the gamma-ray burst mystery — at least as far as long-duration bursts are concerned.

Unfortunately, short-duration bursts, which last less than two seconds, remain "as mysterious as ever," according to Piran. A different mechanism may be responsible for short bursts, namely the merger of two neutron stars. The impetus for this explanation is timing — in the stellar collapse model, the jet has to force its way through the shell of the dead star, a process that takes at least a few seconds. In theory, merging neutron stars release high-energy radiation quickly enough to explain momentary GRBs. While a strong case ties long-duration bursts to the deaths of massive stars, Piran notes, "we don't even have indirect evidence for this other [merging neutron star] scenario."

For his part, Kulkarni speculates the standard energy output that he and his colleagues find perplexing may be "due to the fact that we're only seeing the brightest events. In time, I think we'll see fainter ones and that constancy will go away."

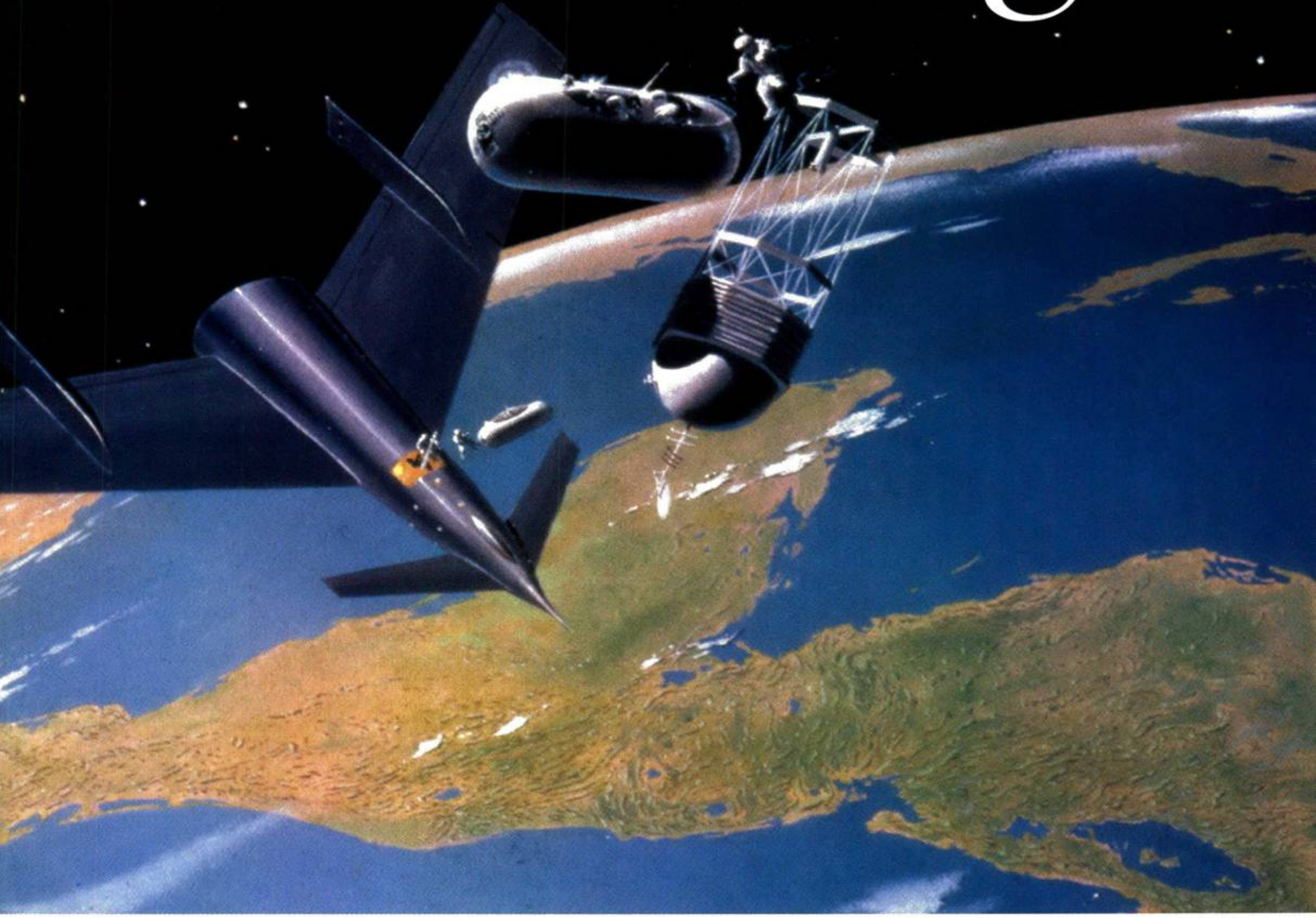
Woosley also is prepared for the prospect that the variety of bursts observed to date is just the tip of the iceberg. A broad range of "optical transients" — emanating from supernovae, novae, flare stars, and active galactic nuclei — has been cataloged in the past, he says, "and there are likely to be forms of gamma-ray transients we don't know anything about."

So it looks like gamma-ray sleuths won't be putting themselves out of business anytime soon. Just as one GRB mystery is solved, other quandaries draw our attention back to these errant jets from the far reaches of the cosmos. ■

To learn more about gamma-ray bursts, visit www.astronomy.com/toc

"Space travel is utter bilge."

— attributed to Sir Richard Wooley, British Astronomer Royal, 1956



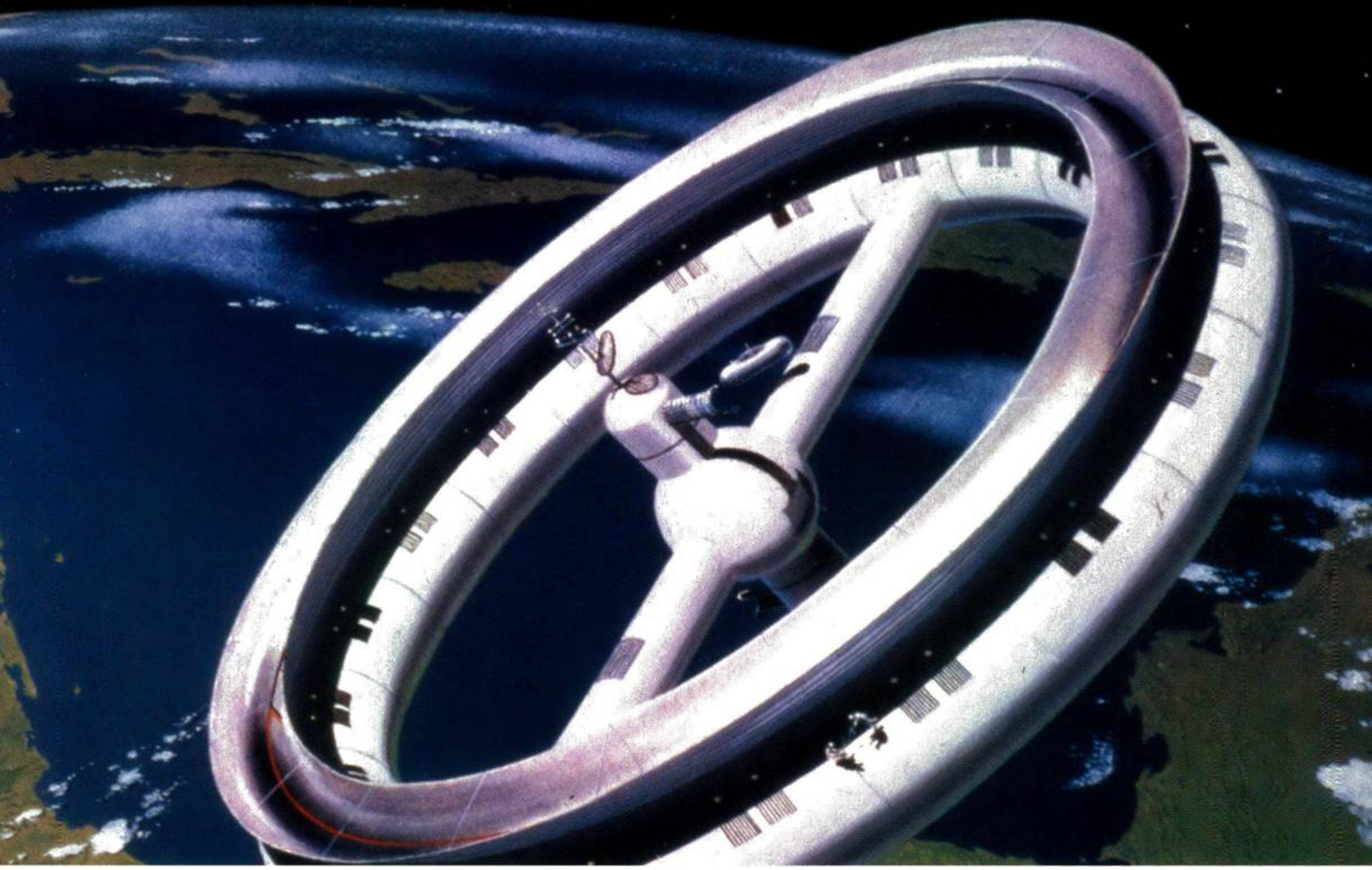
INTERPLANETARY TRAVEL CONTAINS A DEEP PARADOX. Building and flying spacecraft involve science and engineering to a degree unparalleled by any other endeavor. Yet throughout human history, it was the space-flight dreamers who usually turned out to be uncannily farsighted and correct. Eminent scientists were often far too conservative.

Aviation's dreamers had it easier. They could simply point to the birds to show that air would one day support human flight. Traveling into space, however, had no ready-made example — it was accessible only through flights of the imagination.

Dreams of space flight are as old as antiquity. But they started to become grounded in fact only in the 17th century, once scientists began to understand how the universe actually works. Noted astronomer Johannes Kepler wrote a treatise titled *Somnium* (*The Dream*). Its central character, Duracotus, takes a voyage to the Moon. Once in space, Duracotus protects himself from the rarefied air by applying damp sponges to his nostrils. He also notes that propulsion is no longer necessary once he has ascended beyond Earth's orb. The English bishop Francis Godwin published another lunar fantasy titled *The Man in the Moone* in 1638. Its hero, stranded on an island, trains a flock of swans to fly him back to civilization. But the birds take him to the Moon, whose inhabitants stand taller than people due to the lesser lunar gravity.

The first dreamer to consider the practicalities of space flight was a Russian schoolteacher, Konstantin Tsiolkovsky. Born in 1857, Tsiolkovsky contracted scarlet fever as a child and became

For centuries, space flight remained in the realm of dreams — until a few dreamers with slide rules made it happen. /// BY DONALD YEOMANS /// PAINTINGS BY CHESLEY BONESTELL

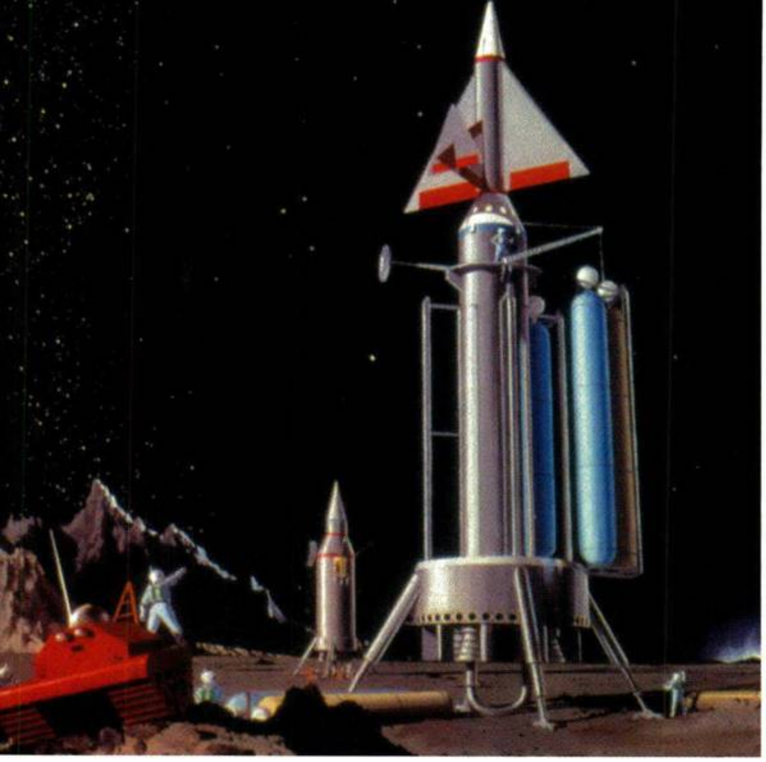


> Earth is the cradle of mankind, but man cannot live in the cradle forever.
> – Konstantin Tsiolkovsky, 1911

mostly deaf. Unable to attend local schools, he studied natural science on his own. In 1879, he passed his teaching examinations and began his career outside Moscow in Kaluga province. What spare time he had was devoted to aeronautics research.

At age 26, he published a short treatise entitled *Free Space*, which stated the path to space required rocket propulsion. Rockets were certainly not new, but Tsiolkovsky was the first to note that only rockets could serve the needs of space travel. He had other forward-thinking ideas too, including a theory of rocket travel that took into account the rocket's changing mass, using liquid hydrogen and oxygen for fuel, the effects of atmospheric drag and solar light pressure on space vehicles, the nature of weightlessness in space, and geosynchronous orbits whereby a satellite could remain above a single location on Earth.

Tsiolkovsky's ideas found neither easy acceptance nor support. Until the Bolshevik Revolution in 1917, he was either ignored or considered crazy by the scientific community in Russia. However, his ideas for using technology to overcome gravity meshed with the Marxist philosophy that machines are indispensable to the construction of Communist society. Thus in 1919, the ruling Communist Party yanked Tsiolkovsky from obscurity and



ON THE MOON, the crew unloads used fuel tanks for living quarters (1961).

appointed him to the Soviet Academy of Sciences. In 1921, at the age of 64, he received a pension that allowed him to work entirely on scientific research. Tsiolkovsky still worked alone, but he now had government funding to publish his writings. In the 1920s, these began to receive international recognition.

Parallel orbits

Tsiolkovsky's life had certain parallels with that of American rocket pioneer Robert Hutchings Goddard, born in 1882. Goddard also worked in relative obscurity and received little credit until after his death in 1945. Like Tsiolkovsky, Goddard taught school — he was a professor at Clark University in Massachusetts. But while Tsiolkovsky never attempted to build a rocket, Goddard developed and launched various models, in addition to conceiving many new ideas for rocket flight.

In 1920, Goddard published a slim paper titled *A Method of Reaching Extreme Altitudes.* In it, he provided calculations on the minimum-size rocket needed to lift a one-pound weight to various altitudes in the atmosphere. He also told how to use flash powder to make a burst of light on the Moon that could be detected from Earth. Goddard, however, was completely unprepared for the notoriety that followed. The press called him "Moon Man" and made him the butt of jokes. Never outgoing to begin with, Goddard responded by withdrawing into seclusion, thus his work was not generally known during his lifetime.

Goddard launched the first liquid-fuel rocket in Auburn, Massachusetts, in March 1926. It reached an altitude of 41 feet (13 meters) and covered a distance of 184 feet (60m), roughly comparable to the Wright brothers' second airplane flight. As had Tsiolkovsky, Goddard realized liquid-fuel rockets were more efficient than those powered with solid fuels such as gunpowder.

With a Guggenheim grant, Goddard and a few assistants established a research facility near Roswell, New Mexico. Between 1930 and 1941, they undertook one of the most amazing lone-wolf efforts in the history of technology. Goddard's liquid-fuel rockets reached speeds of 700 mph (1,100 kph) and altitudes above 8,000 feet (2,600m). His innovations included fuel-injection, regenerative cooling of combustion chambers, gyroscopic control, guidance vanes in the exhaust plume, gimbaled and clustered engines, and lightweight aluminum fuel and oxidizer pumps.

By the early 20th century, Tsiolkovsky and Goddard had shown that space flight was possible, proving Isaac Newton's formulation that for every action there is an equal and opposite reaction. Nevertheless, many people still held the mistaken belief that flying a rocket in space was impossible because "there was nothing for the rocket to push against."

Space flight, with a German accent

Fortunately, a new generation of dreamers — many from Germany — combined technical expertise with a commitment to space flight. One of these dreamers was Hermann Oberth, born in Transylvania, Hungary, in 1894. From boyhood, Oberth was fascinated by space travel. By 1920, he had derived the formulas to calculate the impulse necessary to achieve escape velocity. Oberth produced a doctoral dissertation at the University of Heidelberg on rockets and interplanetary travel. But because neither his advisor, the well-known astronomer Max Wolf, nor anyone else on the faculty would declare themselves competent in the subject, he was unable to submit it for a degree.

> There is no hope for the fanciful idea of reaching the Moon because of insurmountable barriers to escaping the Earth's gravity.
> – Forest Ray Moulton, University of Chicago astronomer, 1932.

Today, *The Rocket into Interplanetary Space* is a classic of space flight theory. In it, Oberth establishes that a rocket can operate in a vacuum and go faster than the speed of its own exhaust. He also discusses alcohol and hydrogen as rocket fuels. In the only section relatively free of complex equations, Oberth explores the physiological and psychological problems of manned flight, including acceleration, weightlessness, loneliness, and claustrophobia.

During the 1920s, while the work of Oberth was being discussed within a small circle of followers in Europe, and the work of Goddard was followed closely by an even smaller group of American dreamers, the general public still remained oblivious to space flight's possibilities. In Germany, however, the spark of interplanetary travel was fanned by two other dreamers — Walter Hohmann and Hermann Noordung.

Smooth trajectories

Born in 1880, Hohmann became city architect in Essen. A civil engineer by day, he spent his free time investigating space travel. His book *The Attainability of the Heavenly Bodies,* published in 1925, advanced such modern ideas as the variable-pitch wing, nose cones and parachutes for landing, making fuel from off-planet resources, and surface landers that detach from planetary orbiters. Hohmann is best remembered, however, for what is

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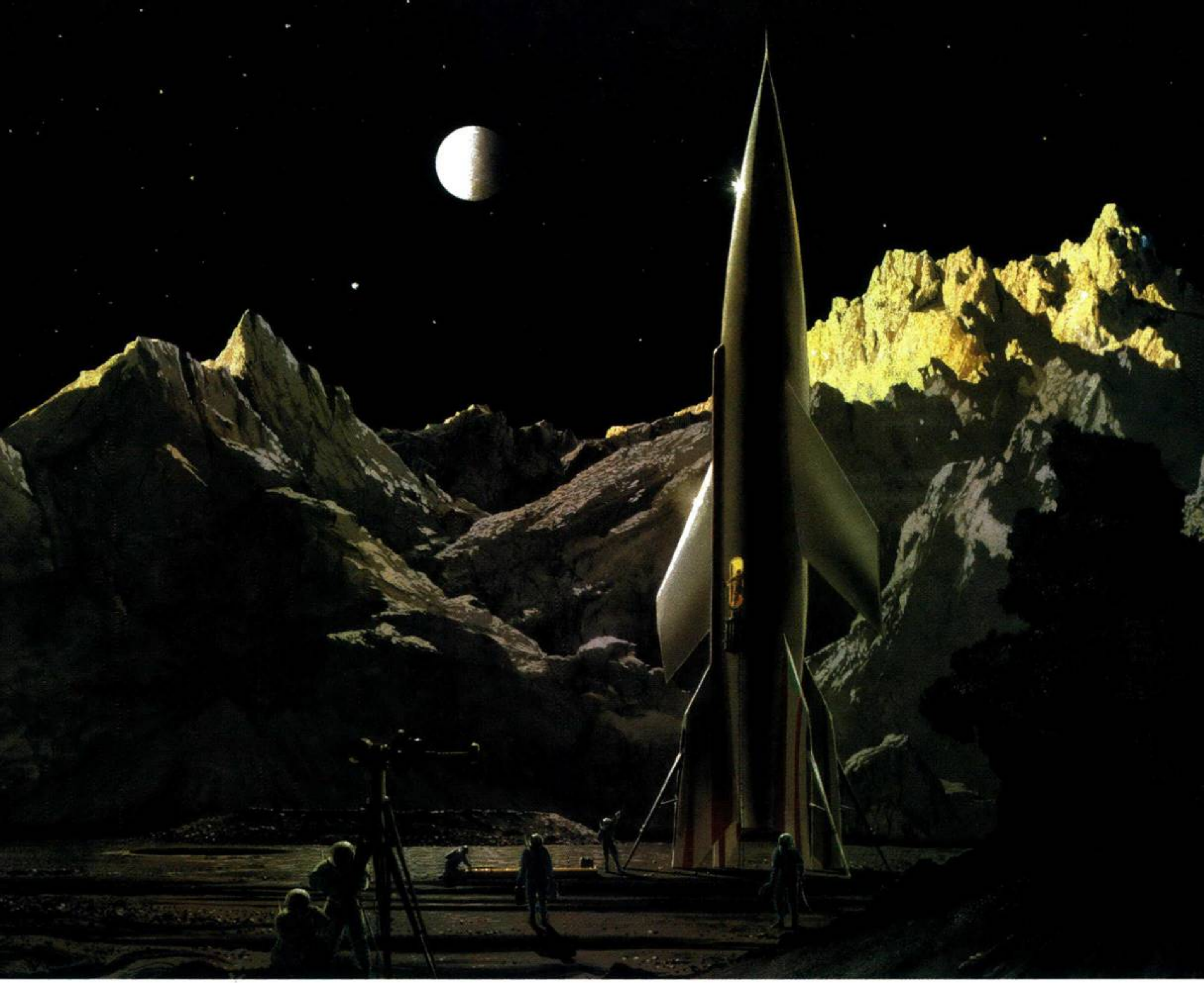
Donald Yeomans *is senior research scientist at the Jet Propulsion Laboratory in Pasadena, California. He also manages NASA's Near-Earth Object Program office.*



THE MOON SHIP STANDS ON ITS FINS, poised for return to Earth. Its resemblance to the wartime V2 reflects the design heritage of Wernher von Braun (1949).

known today as the Hohmann trajectory — the idea that the lowest-energy pathway between any two planets is an ellipse that just touches the orbits of both.

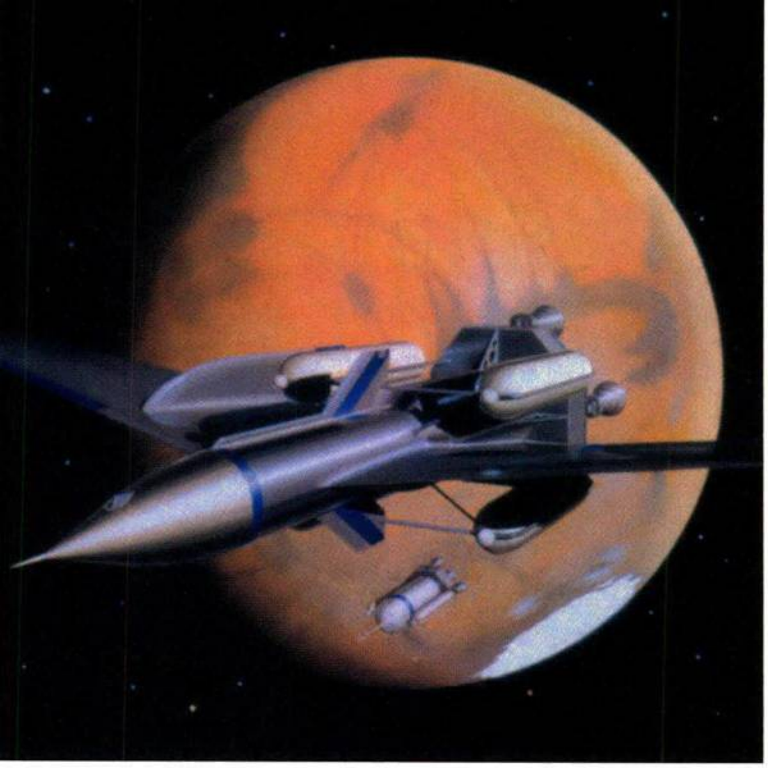
Hermann Noordung (whose real name was Herman Potocnik) was an Austrian army officer. His life was cut short by tuberculosis in 1929 (he was 38), but the year he died saw publication of his classic book *The Problem of Space Travel*. Although much of the book drew from Oberth's work, Noordung proposed an impressive number of innovative ideas, particularly with regard to space stations. He described using air locks and space suits, and he suggested that gyroscopes could maintain control of a spacecraft's orientation in flight. Noordung also recommended putting a space station in geosynchronous orbit. Finally, he proposed space stations as sites for experiments in the absence of gravity and heat, as astronomical observatories, and as platforms for parabolic space mirrors for weather control and military purposes.

In 1927, Oberth, Hohmann, Wernher von Braun, Willy Ley, and other German space enthusiasts formed the Society for Space Travel (*Verein für Raumschiffahrt*, or VfR). They worked toward the day when rocket technology could send spacecraft to explore the solar system. But this club of rocket enthusiasts was operating on the margin: Research was largely self-funded, and their rocket experiments did not attract the government support needed to get beyond the hobbyist stage.

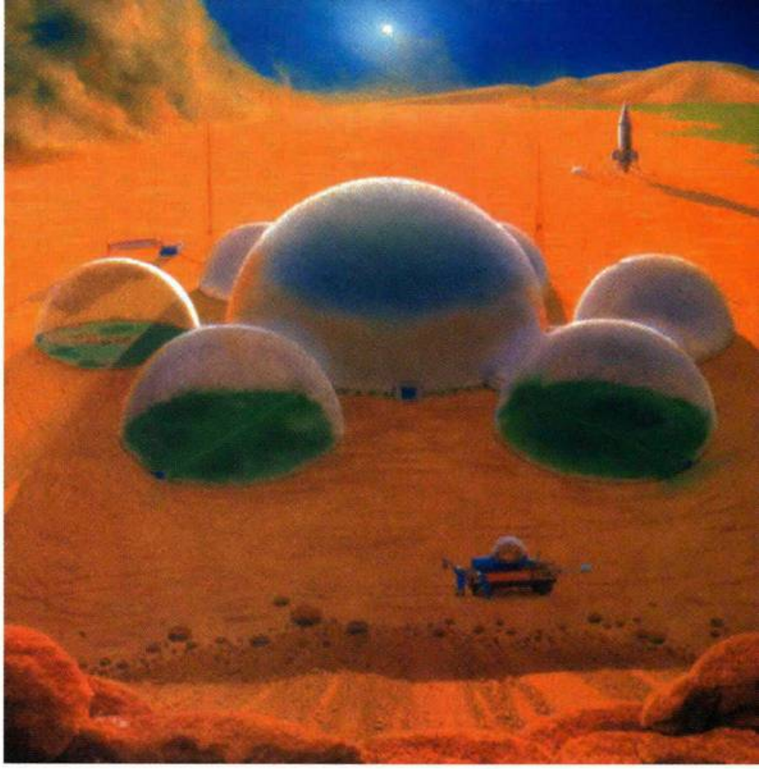
> The younger generation of rocket engineers is just beginning. They are of the new generation to which space travel is not going to be a dream of the future but an everyday job with everyday worries in which they will be engaged.
> – Willy Ley, space-flight pioneer and historian, 1951

Deal with the devil

Ultimately, the German army stepped in to sponsor the development of rocket flight. In 1932, it hired several VfR members, including von Braun, to work in a rocket artillery unit. Von Braun was soon in charge of an expanding rocket-building program, and



APPROACHING MARS, the ship prepares to brake into orbit (1956).



A MARS COLONY GROWS under plastic domes like a hothouse plant (1964).

when Hitler and the Nazi Party took over Germany in 1933, von Braun was assigned to oversee long-range missile development. He was just 21 years old.

Over the next dozen years, von Braun steered the Nazi rocket program, based at Peenemünde, Germany. His group made rapid strides in developing a long-range, reliable liquid-fuel rocket. The effort culminated in the V2 missiles that Hitler fired at England during the last months of World War II.

The V2s were built by slave laborers, 25,000 of whom died in hellish conditions at the underground Mittelwerk factory and the Dora concentration camp. These deaths outnumbered tenfold the toll of British civilians killed in the V2 attacks. Von Braun's culpability in this atrocity has been noted more than once. A Nazi Party member, he also held the rank of major in the SS. Nevertheless, in May 1945, he and his brother Magnus surrendered to American forces, expecting the United States would value their expertise. Indeed, the United States made extraordinary efforts to ensure that the von Brauns and other top Nazi rocket scientists would remain in American, rather than Soviet, hands. The Cold War was spreading, and the American military was counting on its captured German rocket scientists to develop the next generation of weapons delivery systems.

> To place a man in a multi-stage rocket and project him into the controlling gravitational field of the Moon . . . . I am bold enough to say that such a man-made voyage will never occur regardless of all future advances.
> – Lee De Forest, radio pioneer, February 25, 1957

Red star rising

Whatever his principles, Wernher von Braun had unquestioned leadership abilities and an unparalleled grasp of rocket engineering. When the U.S. Army put him in charge of developing military rockets, his dream of using them for space flight was shelved. Von Braun continued to promote manned space flight, writing books and articles on the subject, but they had little impact until the American public and Congress demanded a response to the Soviet Union's launch of the first Earth satellite, Sputnik, on October 4, 1957. Working in secrecy, the Soviets' chief rocket designer, Sergei Korolev, had developed an impressive missile program whose scale and capabilities frightened the American public.

The USSR put a second satellite (this time carrying a dog named Laika) into Earth orbit on November 3, 1957. Finally, the United States successfully launched its own Earth-orbiting satellite, Explorer 1, on January 31, 1958. Explorer's key components were a rocket developed by von Braun's team and a satellite built by Caltech's civilian-run Jet Propulsion Laboratory. The satellite carried a detector developed by James Van Allen that discovered charged particles ensnared in the Earth's magnetic field, a region now known as the Van Allen radiation belts.

By the late 1950s, however, the era of the space-flight dreamer was rapidly drawing to a close. Cold War rivalries placed a value on space flight that most polticians and national leaders recognized clearly. The basic argument for space flight had been won, and hands other than the dreamers' were on the throttle. Yet despite being long marginalized and ridiculed, these otherworldly minded people had helped bring about a revolution in human affairs — the conquest of space.

"Centuries hence," said planetary scientist Carl Sagan, "when current social and political problems may seem as remote as the problems of the Thirty Years War are to us, our age may be remembered chiefly for one fact: It was the time when the inhabitants of the Earth first made contact with the vast cosmos in which their small planet is embedded."

To learn more about dreams of space flight, see "Yesterday's tomorrows" at www.astronomy.com/toc

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Meade
Meade has set the bar higher with the new SMT Smart Drive Software/ Mount system. The Smart Drive can teach itself to become more accurate each time you use it. Whether it's on the ETX, LXD55, or LX200, the best just got better.

Pentax
If Pentax advertised, everyone would know that they make the best eyepieces. The new XW series (extra wide, from 3.5mm to 40mm) offers the best in contrast, sharpness, and comfort, with long eye relief and a screw down eyecup.

Celestron
The new CGE GoTo Mount Series is second to none in its class. Designed for precision and remarkable portability, it has no dangling wires and no bolt-on extras. GPS is available, and it carries a two year warranty. It's a perfect match for any quality instrument up to 14 inches.

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Takahashi has been the standard for a generation. The new TOA 130 APO may be the best telescope made. Most Takahashi's are available from stock. Why wait? Why get second best?

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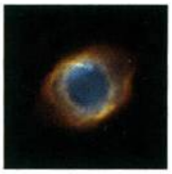

0080 Helix Nebula

0004 Saturn 1

0074 Cluster Abell 1689

0082 Pencil Nebula

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BY MARTIN RATCLIFFE AND ALISTER LING

JANUARY 04

Brilliant Venus begins a series of spectacular conjunctions, a prelude to its climax coming this spring.

Venus and Saturn vie for honors

Impossible to miss, the blazing beacon in the southwestern sky after sunset is our sister planet Venus, not the landing light of an airplane. Mars may have been bright last summer, but it doesn't hold a candle to the goddess of love. Venus is bigger than Mars, comes closer to Earth, and is completely covered with reflective clouds. ☾ Over the next couple months, Venus slowly climbs away from the twilight glow and into a darker sky, dominating the evening stage. In March, you'll be able to find it during the daytime, and at night, spot your shadow cast by its bright light. In January, you can use Venus as a signpost to locate Uranus on the 14th and 15th, when the outer planet nestles among a nice string of stars. Watch for a lovely crescent Moon below Venus on the 23rd; the next night, the two will be an awesome pair through binoculars.

PLANETARY CONJUNCTIONS abound this year. An excellent pairing of Venus and the Moon on the 24th will be much closer than this one from 1998. RANDALL WEHLER

Sure to make some headlines, Saturn reached opposition on the afternoon of December 31. This means that in early January, the Ringed Planet lies opposite the Sun in our sky, rising at sunset and remaining visible all night long. On the evening of January 6, Saturn rises paired with the bright Moon, only a day from full phase. Without doubt, this gas giant is the showpiece of the month (see "Saturn in prime time" on page 88). Wait until later in the evening before turning your telescope toward Saturn. Earth's turbulent atmosphere typically blurs objects low in the sky.

Tiny Mars may not be much to look at telescopically this month, but it should be fun to watch the spectacular images arriving from NASA's two Mars Exploration Rovers.

Jupiter, the heavyweight of the planets, is a late riser. With its complex cloud belts, spots, barges, and festoons, Jupiter always will be a favorite of skywatchers. The four bright moons, discovered by Galileo nearly four hundred years ago, promenade slowly around the gas giant and regularly cast their shadows onto the cloudtops. Sometimes two shadows can be seen simultaneously. Best views come well after midnight, when the planet lies higher in the sky, but we'll understand if you submit to temptation and take a peek earlier. The Moon passes nearby Jupiter on the nights of January 11 and 12.

Lonely Mercury lurks quietly in the southeast as dawn progresses. Compare the planet's glow to the twinkling orange star Antares to its upper right. Scan the sky with binoculars because neither object will be as obvious as the other planets. The waning crescent Moon slides past Antares on the morning of the 18th. The next morning, use the Moon as a signpost and slide two binocular fields to its left to land on Mercury.

Earth reaches its closest point to the Sun in January. Perihelion occurs at 1 P.M. EST on the 4th but brings no warmth to our northern winter. The tilt of our axis away from the Sun in winter makes all the difference.

The depths of space visible to us are populated by so much more than just planets. Using binoculars from your backyard, you can check out the bright asteroid 1 Ceres. A trip away from city lights and into darker skies allows you to plumb the deep sky for star clusters and gas clouds. And any small telescope can show you C/2002 T7 (LINEAR), an icy comet set to put on a big show this spring.

NEW Celestron StarBright XLT High Performance Optical Coatings Outperform The Competitor's UHTC.

StarBright XLT — An Optical System Breakthrough! Celestron has taken its renowned StarBright technology to *an even higher level of light transmission* with the introduction of our new **optional** StarBright XLT High Performance Optical Coating System.

StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

- **11% brighter than UHTC across the spectrum from 400nm to 750nm.** (See Fig.#1)
- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

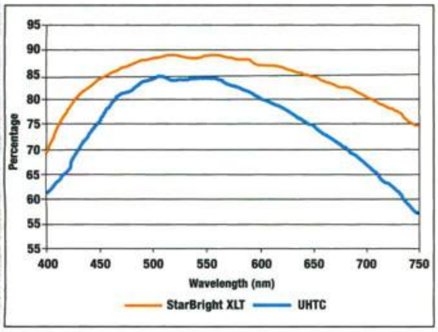

*Fig #1: This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

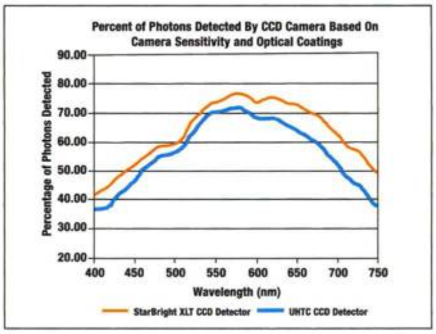

*Fig #2: StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO_2 (quartz), TiO_2 (titanium dioxide), and SiO_2. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of MgF_2 (magnesium fluoride), and HfO_2 (hafnium oxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings.*** That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

For more information about StarBright XLT visit: www.celestron.com/starbrightxlt

Coming Out of the Dark — StarBright XLT Performance Where It Counts

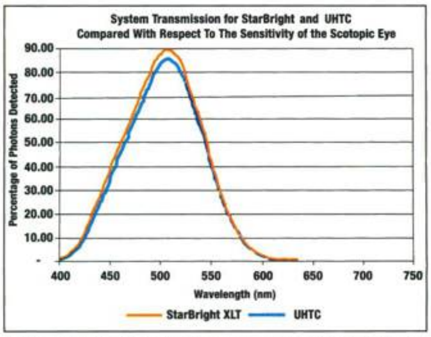

Fig #3: The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a ***6% improvement over UHTC*** *for visual observing .**

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt.***

****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products	$125
All 9.25" Schmidt-Cassegrain Products	$175
All 11" Schmidt-Cassegrain Products	$225
All 14" Schmidt-Cassegrain Products	$275

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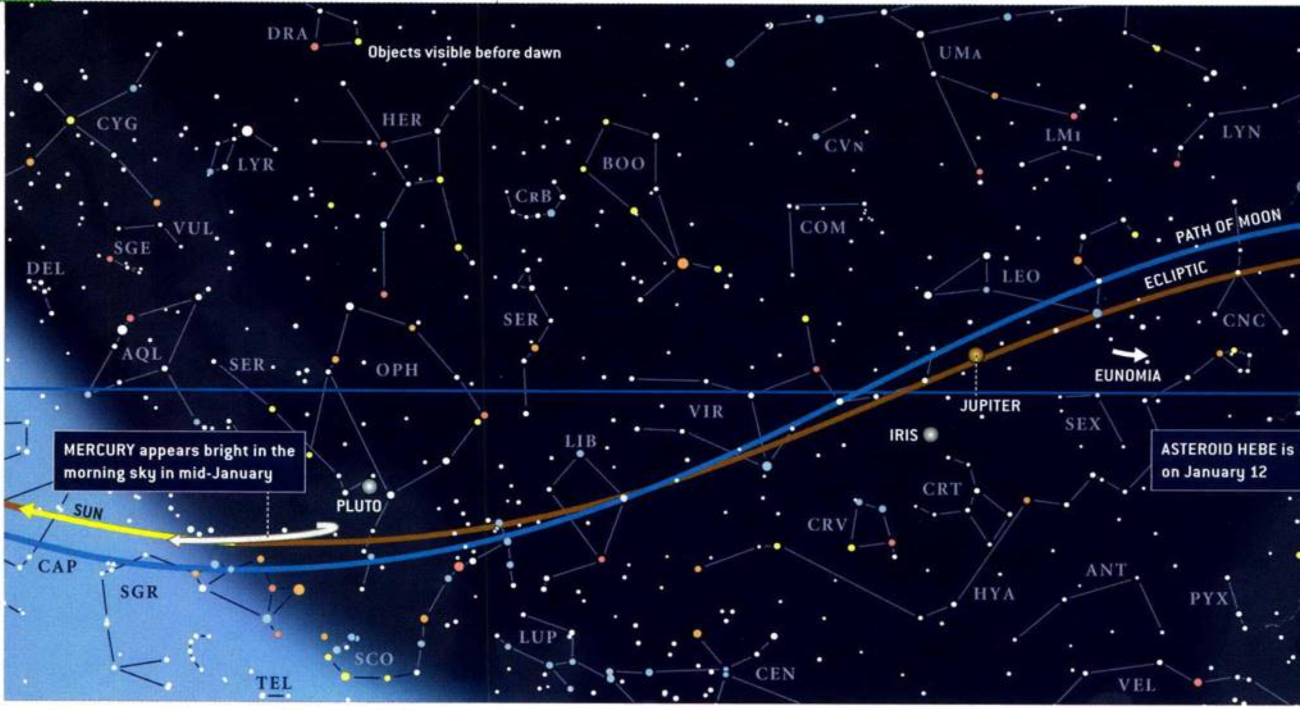
Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and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IRIS
LIB
SUN
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CRT
CRV
CAP
SGR
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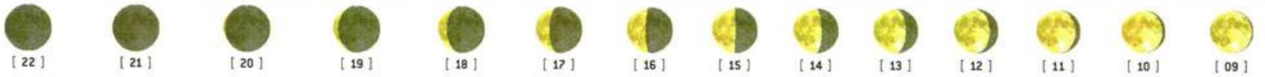
Objects visible before dawn

MERCURY appears bright in the morning sky in mid-January

ASTEROID HEBE is on January 12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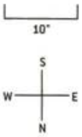
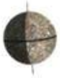
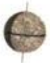
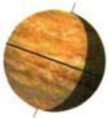
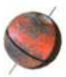
To locate the Moon in the sky, draw a line from the phase shown for th







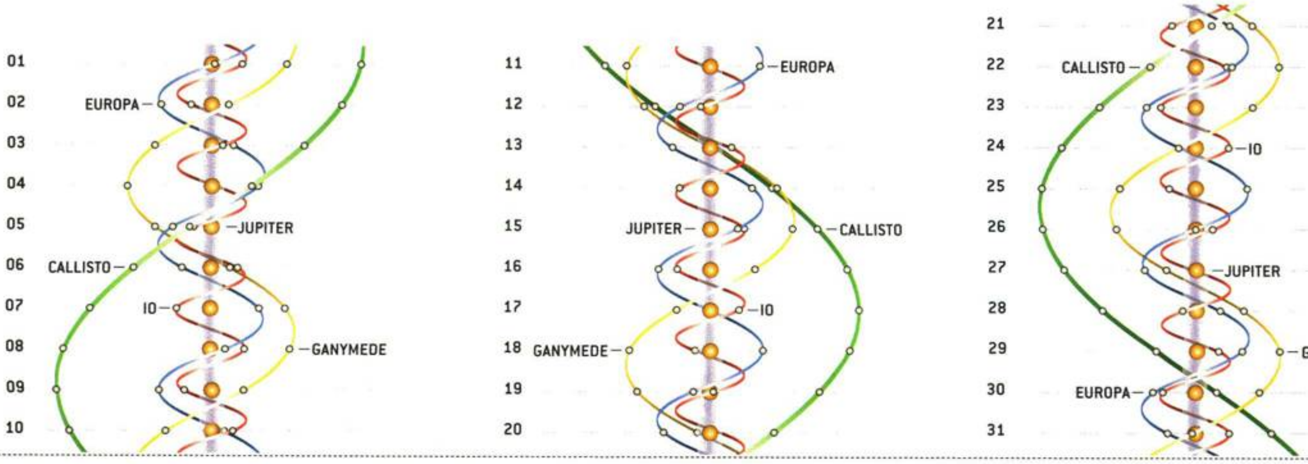




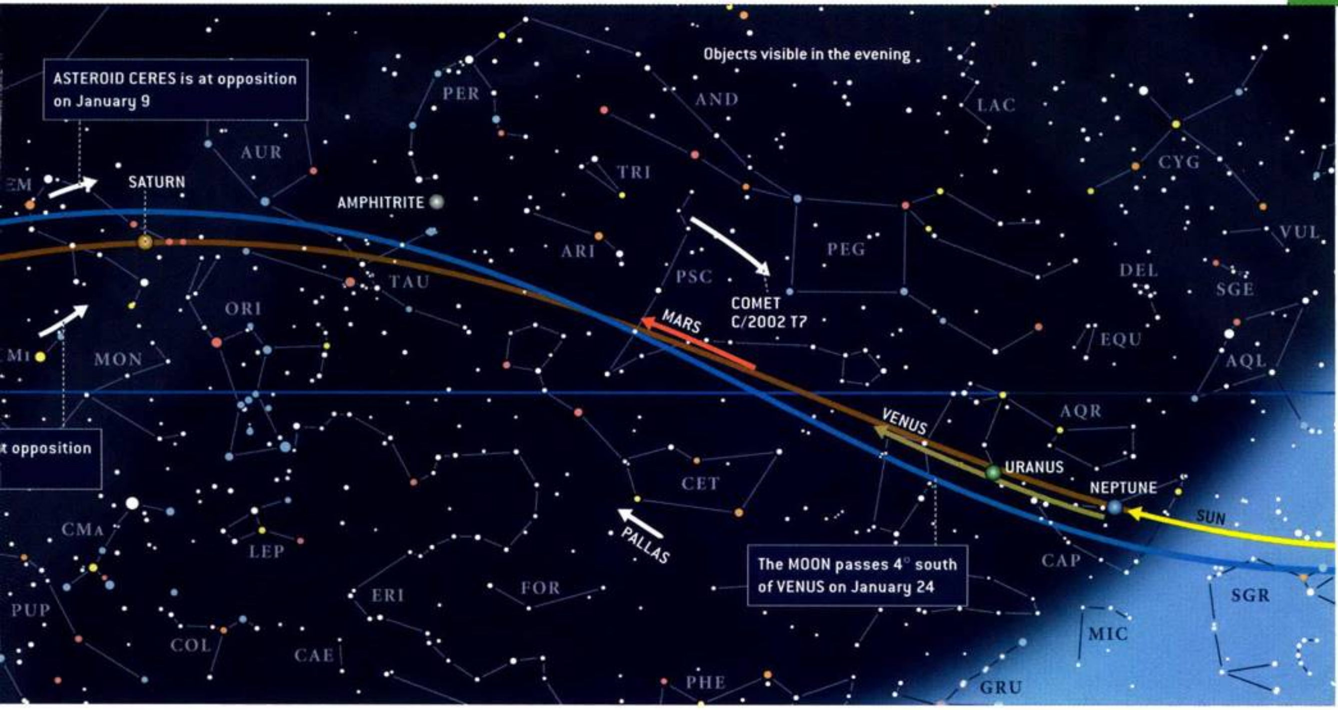
PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	January 15	January 31	January 15	January 15
Magnitude	−0.1	−0.2	−4.0	0.5
Angular Size	7.0"	5.5"	13.6"	7.6"
Illumination	58%	82%	80%	88%
Distance (AU) from Earth	0.965	1.220	1.227	1.237
Distance (AU) from Sun	0.402	0.461	0.725	1.492
Right Ascension (2000.0)	18h01.8m	19h24.9m	22h11.8m	1h04.8m
Declination (2000.0)	−21°37′	−22°33′	−12°52′	7°17′

Jupiter's moons

Dots display positions of Galilean satellites at 4 A.M. EST on date shown. South is at top to match the view in a telescope.



colored dots show motions and locations of solar system objects during the month.


Objects visible in the evening
PER
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LAC
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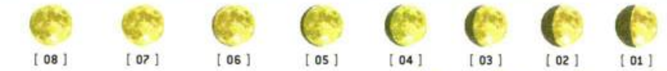
ASTEROID CERES is at opposition on January 9

The MOON passes 4° south of VENUS on January 24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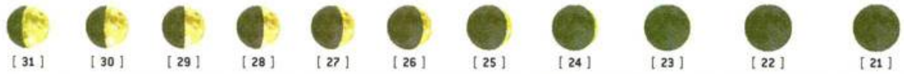
day straight up to the curved light-blue line.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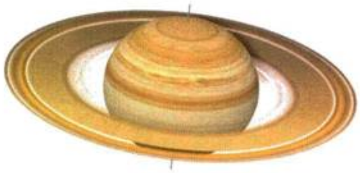
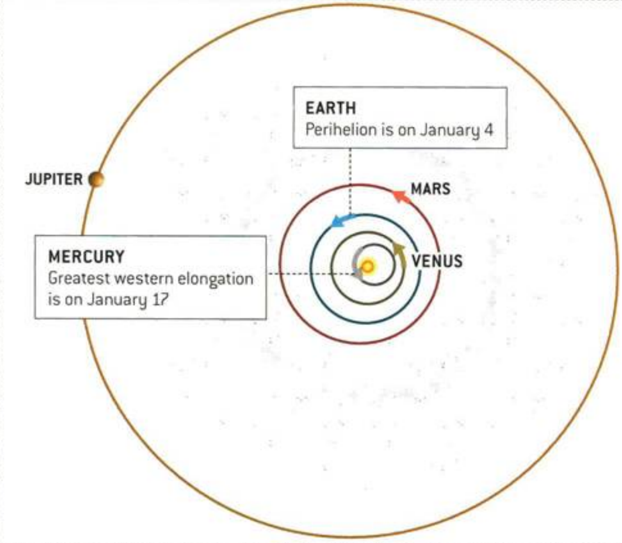


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
January 15	January 15	January 15	January 15	January 15
−2.3	−0.4	5.9	8.0	13.9
41.3"	20.6"	3.4"	2.2"	0.1"
99%	100%	100%	100%	100%
4.777	8.082	20.821	31.008	31.554
5.407	9.034	20.039	30.075	30.745
11h20.3m	6h37.1m	22h11.9m	20h58.4m	17h23.0m
5°40'	22°31'	−11°55'	−17°11'	−14°31'

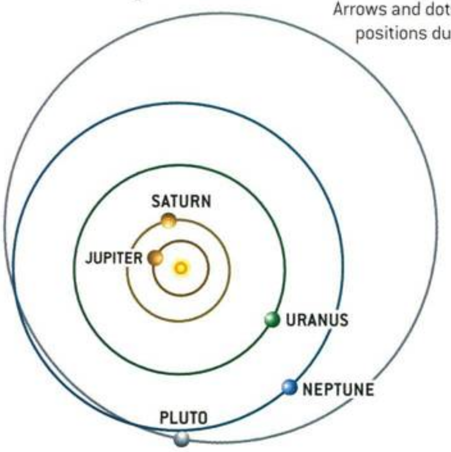
The planets in their orbits

Arrows and dots show planets' positions during the month.


JUPITER
MARS
VENUS

EARTH
Perihelion is on January 4

MERCURY
Greatest western elongation is on January 17


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

We've added a new dimension to our NexStar® GPS family of GoTo telescopes.

NexStar 11 GPS

NOW AVAILABLE WITH
StarBright® XLT
HIGH PERFORMANCE
OPTICAL SYSTEM
For more information, visit: www.celestron.com/starbrightxlt

Introducing the NexStar 9.25 GPS.

The Celestron 9.25" optical tube was already a favorite among astrophotographers and discerning visual observers, but now with the **carbon fiber tube** and the **NexStar GPS mount**, it is a formidable addition to the NexStar GPS family. The 9.25 was **specifically designed for visual infinity focus when using 2" eyepieces** and has an **optimized baffle system** to benefit astrophotography by minimizing vignetting at the edge of the field of view. Its **longer primary focal length** and **lower magnification secondary mirror** contribute to a flatter field of view at the focal plane and helps to further reduce optical aberrations. ***This feature-packed model comes standard with a carbon fiber tube and Celestron's renowned StarBright® multi-coatings.*** The NexStar 9.25 GPS is compatible with the complete line of Celestron photographic and visual accessories.

NexStar 9.25 GPS**

What makes the NexStar 9.25 GPS great for astrophotography?

- **Longer focal length primary and lower magnification secondary** — Contributes to a flatter focal plane with less coma and off-axis astigmatism.
- **Baffle design** — Optimized for astrophotography. Minimizes vignetting at the edge of the field of view. This reduces light drop off at the corners of your film plane.

NexStar GPS. Quality that's designed in — not added on.

NexStar GPS Standard Software Features:

- **GPS Align** – Press the Align button and the telescope will automatically begin its alignment sequence.
- **Database** – 40,000 + objects in database.
- **Magnetic North Compass Compensation** – Magnetic north and true north are not the same; magnetic north varies depending upon your position on the earth. The NexStar allows you to compensate for the variation. This improves pointing during the automated GPS alignment process.
- **Quick Align** – Gets the telescope tracking the sky without actually aligning it to two stars. Useful for tracking planets or solar observing.
- **EQ Auto Align** – The telescope will automatically pick and slew to your alignment stars even in equatorial mode.
- **Polar Alignment Routine** –The NexStar has a polar alignment algorithm making polar alignment easy and accurate for equatorial use.
- **User-defined Filter Limits** – When filter limit is set, the hand control will only display objects above the horizon or as set by the user.
- **User defined Slew Limits** – Set the maximum and minimum slew limits on the altitude axis.

NexStar 8 GPS

Quality Components:

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
- 32-pitch, 5.625" pitch diameter, 180-tooth Bronze gear.
- Stainless steel worm shaft.
- Precision annealed Pyrex primary and secondary mirrors.
- **Carbon Fiber Tube** –1/4 the thermal expansion of aluminum; creates a more stable focus. The tube is four times more resistant to temperature changes than aluminum tubes; minimizes your need to re-focus.

Intelligent Design:

- Built-in 16-channel GPS receiver, magnetic compass and internal altitude switch work together to fully automate the alignment process.
- **Internal Slip Ring** – Eliminates power cable wrapping.
- **Auxiliary ports are located on the rotating base** – Auxiliary port rotates with the telescope; vastly improves cable management.
- **Ergonomic design** - Carrying handles strategically placed for improved lifting power and stability; hand control integrated in fork arm for ease of use whether on the scope or in your hand.
- **Optical Tube Assembly Mounting Rails** – An outer rail on each side of the optical tube provides rigid, flex-free movement.
- **Unique roller bearing and shaft design** – The telescope base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounted for imaging.

Standard Equipment & Specifications

	NexStar 8 GPS	NexStar 9.25 GPS	NexStar 11 GPS
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	Yes
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	$1999	$2699	$2999
Shipping & Handling	$95	$115	$125

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**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included. ***120V AC Adapter included for U.S.A. and Canada only.

CELESTRON ACCESSORIES

FOR MORE INFORMATION OR TO LOCATE AN AUTHORIZED CELESTRON DEALER, VISIT: WWW.CELESTRON.COM

OMNI® Eyepieces — 11/4"

- Focal lengths – 4mm, 6mm, 9mm,12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52º (43º for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens — 11/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow............$ 47.00

X-Cel® Eyepieces — 11/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm,10mm, 12.5mm,18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

2.3mm	$ 69.00	12.5mm	$ 69.00
5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

E-Lux® Eyepieces 2"

- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces — 11/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plössl optical design
- Fully-coated

2":		1-1/4":	
26mm	$ 69.00	6mm	$ 34.00
32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces — 11/4", 2"

- Focal lengths –

1-1/4": 15mm, 19mm, 23mm
2": 19mm, 34mm, 40mm, and 50mm

- **7-element optical design**
- **70° EXTRA WIDE** field of view (except 50mm)
- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
50mm	$329.00

Ultima® Eyepieces — 11/4"

- **5-element hybrid optical design**
- Focal lengths – 5mm, 7.5mm, 12.5mm, 18mm, 30mm, 35mm, and 42mm
- Fully multi-coated
- Blackened lens edges

5mm	$ 79.00
7.5mm	$ 79.00
10mm	$ 79.00
12.5mm	$ 79.00
18mm	$ 79.00
30mm	$ 99.00
35mm	$109.00
42mm	$ 99.00

10mm Plössl Reticle Eyepiece — 11/4"

- Five-element guiding eyepiece
- Reticle pattern is a .0075' double spaced line system
- Multicoated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
- 50° apparent field of view
- Optional illuminator is required

10mm Plössl Reticle Eyepiece —11/4"...........$124.00

Ultima® 2x Barlow — 11/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece — 11/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars

Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C91/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

Stereo Binocular Viewer

- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

Stereo Binocular Viewer.......$649.00

Power Tank™

- 12-volt rechargeable power supply
- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank............$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)............$ 59.00

Contrast-Booster Filter — 11/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter............$ 49.00

Model A — for 1-1/4" eyepieces

Model B — for backthreads of SC's

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"....$ 69.00
LPR Filter Model B......$ 99.00

11/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets — 11/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)	$ 44.00
#94119-20 (12, 25, 56, ND-25)	$ 44.00
#94119-30 (23A, 38A, 58, ND-50)	$ 44.00
#94119-40 (8, ND-13, 47, 82A)	$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision

Night Vision Flashlight.......$ 19.00

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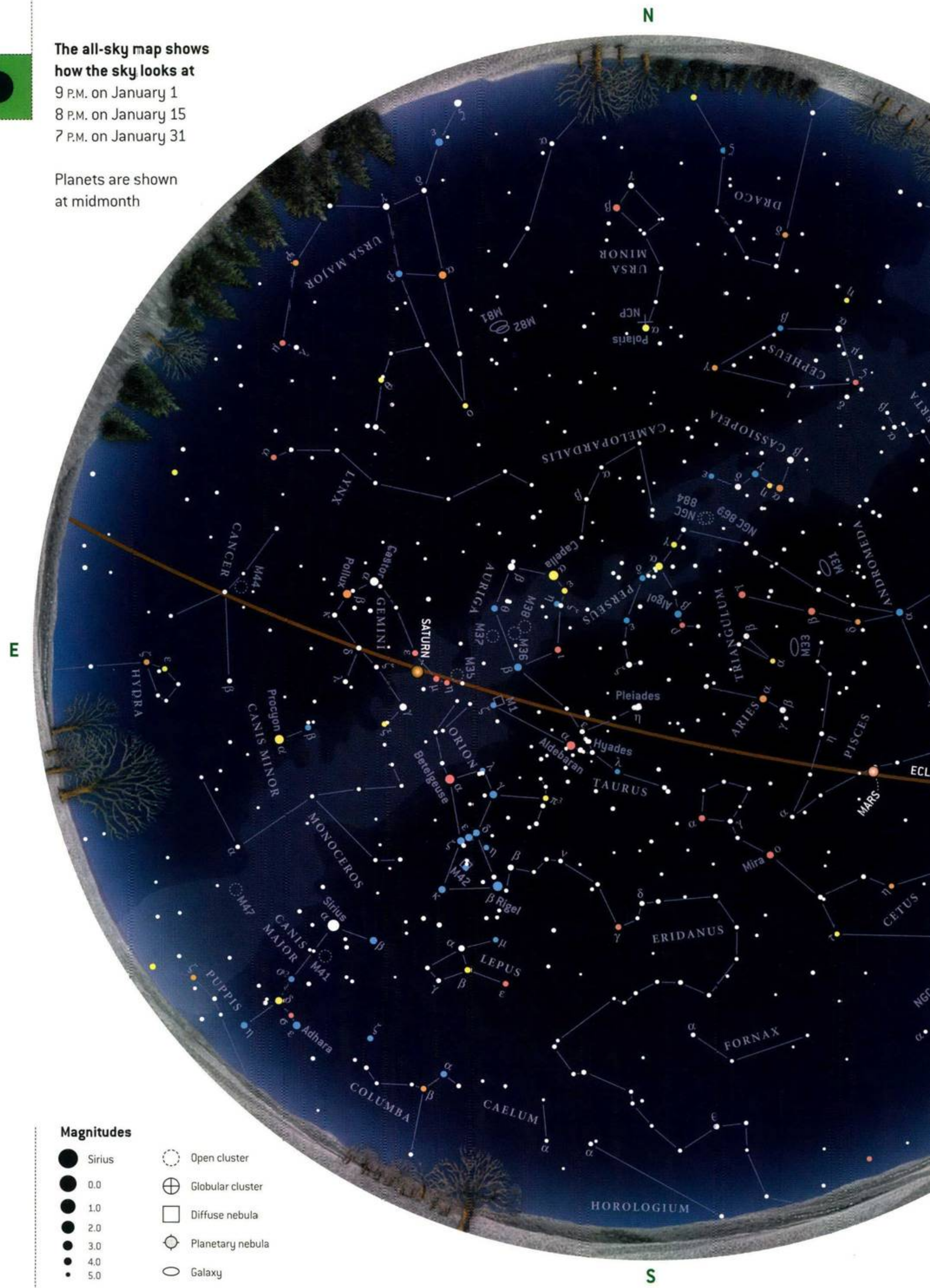
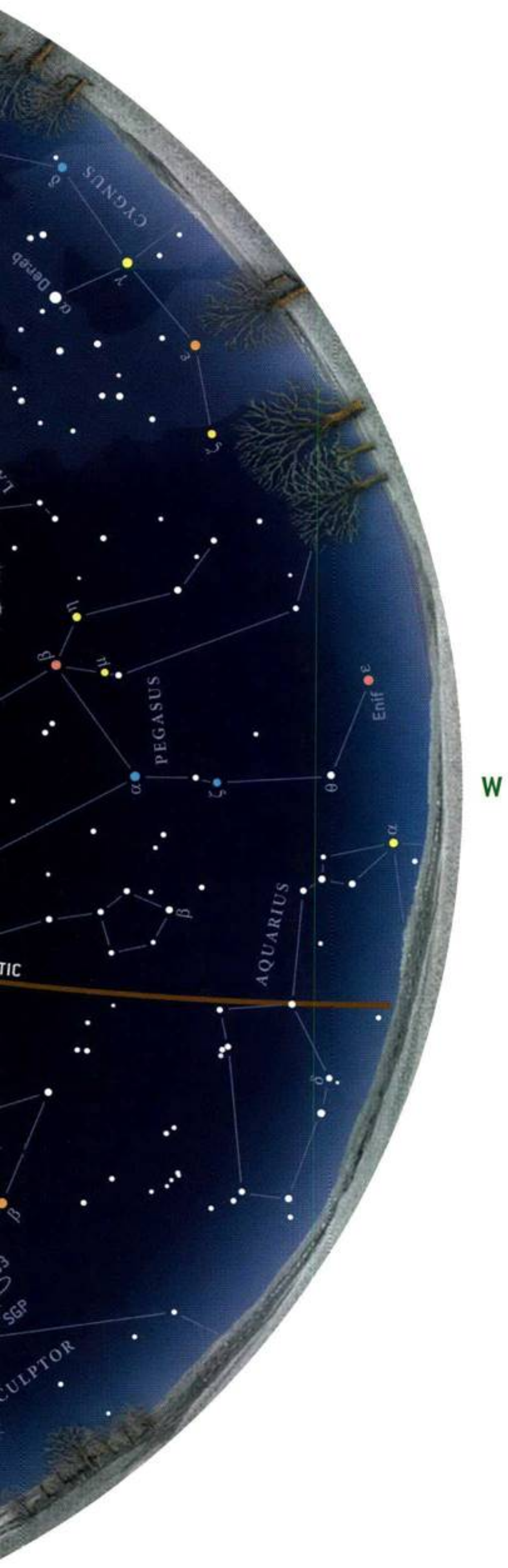
Note: All prices shown are suggested retail mail-order.
All prices shown in U.S. Dollars.

The all-sky map shows how the sky looks at
9 P.M. on January 1
8 P.M. on January 15
7 P.M. on January 31

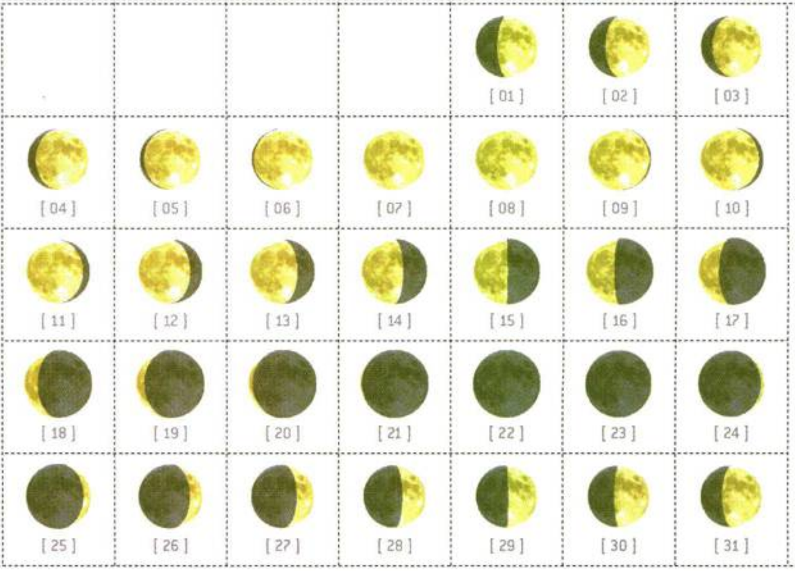
Planets are shown at midmonth


N
E
S
URSA MAJOR
DRACO
URSA MINOR
NCP
Polaris
M81
M82
CEPHEUS
CASSIOPEIA
CAMELOPARDALIS
LYNX
CANCER
M44
Castor
Pollux
GEMINI
SATURN
AURIGA
Capella
M38
M37
M36
M35
PERSEUS
Algol
NGC 869
NGC 884
ANDROMEDA
M31
TRIANGULUM
M33
HYDRA
Procyon
CANIS MINOR
M1
Pleiades
Hyades
Aldebaran
TAURUS
ARIES
PISCES
ECL
MARS
ORION
Betelgeuse
MONOCEROS
M42
Rigel
M47
Sirius
CANIS MAJOR
M41
ERIDANUS
Mira
CETUS
LEPUS
PUPPIS
Adhara
FORNAX
COLUMBA
CAELUM
HOROLOGIUM
NGC
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: no
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



january 04



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
				[01]	[02]	[03]
[04]	[05]	[06]	[07]	[08]	[09]	[10]
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[18]	[19]	[20]	[21]	[22]	[23]	[24]
[25]	[26]	[27]	[28]	[29]	[30]	[31]

03 The Moon is at apogee (252,095 miles from Earth), 3:17 P.M. EST

04 Quadrantid meteor shower peaks

Jupiter is stationary, 10 A.M. EST

Earth is at perihelion (91.4 million miles from the Sun), 1 P.M. EST

06 The Moon passes 5° north of Saturn, 7 P.M. EST

07 Full Moon is at 10:40 A.M. EST

09 Asteroid Ceres is at opposition, 9 A.M. EST

12 The Moon passes 3° north of Jupiter, 6 A.M. EST

Asteroid Hebe is at opposition, 6 P.M. EST

14 Venus passes 0.9° south of Uranus, 8 P.M. EST

Last Quarter Moon is at 11:46 P.M. EST

17 Mercury is at greatest western elongation (24°), 5 A.M. EST

19 The Moon is at perigee (225,415 miles from Earth), 2:25 P.M. EST

The Moon passes 5° south of Mercury, 10 P.M. EST

21 New Moon is at 4:05 P.M. EST

23 The Moon passes 4° south of Uranus, 4 P.M. EST

24 The Moon passes 4° south of Venus, 11 A.M. EST

27 The Moon passes 3° south of Mars, 10 P.M. EST

29 First Quarter Moon is at 1:03 A.M. EST

31 The Moon is at apogee (251,536 miles from Earth), 8:59 A.M. EST

n, south, east, and west. To find stars above your

Here's An Eye-Opening Offer!

Purchase any Celestron telescope and buy this exclusive Filter and Eyepiece Accessory Kit for ONLY $99!*

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32mm PLÖSSL
15mm PLÖSSL
2x Barlow
9mm PLÖSSL
6mm PLÖSSL
4mm PLÖSSL
No. 21
No. 56
No. 80A
No. 12
No. 25
No. 58A
Moon

Seeing is believing!

Purchase **any** Celestron telescope **between September 15, 2003 and December 31, 2003**, and buy this exclusive Celestron Filter and Eyepiece Accessory Kit from your dealer for **ONLY $99**.

The Filter and Eyepiece Kit (#94303) contains:

- **Five Superior Grade Plössl Eyepieces** - 1.25" — 4-element design with a 52 AFOV (32mm has 44°) — Superb color, resolution, edge sharpness and clarity. All eyepieces are fully multi-coated for maximum contrast and resolution. Supplied are a 4mm,6mm, 9mm, 15mm, and 32mm.

Rugged carrying case is included!

- **Barlow Lens** - 2x 1.25" — Compliments the Plössl eyepieces in this kit and gives you a total of ten power combinations. High grade glass optics with fully multi-coated lenses are used so there is no degradation of image.
- **Six Colored Eyepiece (Planetary) Filters** - 1.25" — Included are Kodak Wratten #12, #21, #25, #56, #58A, and #80A. Since you have all the eyepieces necessary to study the planets and moon in detail, these filters will greatly enhance your enjoyment of our solar system.
- **Moon Filter** - 1.25" — A neutral density filter which allows you maximum enjoyment of the moon especially during the brighter phases.
- **Aluminum Carrying Case** — This sturdy and well-built case fits all of the above items in the die-cut foam interior and has room for additional accessories.

***This special $99.00 offer ends Dec. 31, 2003.**

The items in this kit are valued at over $700.00 if purchased separately!

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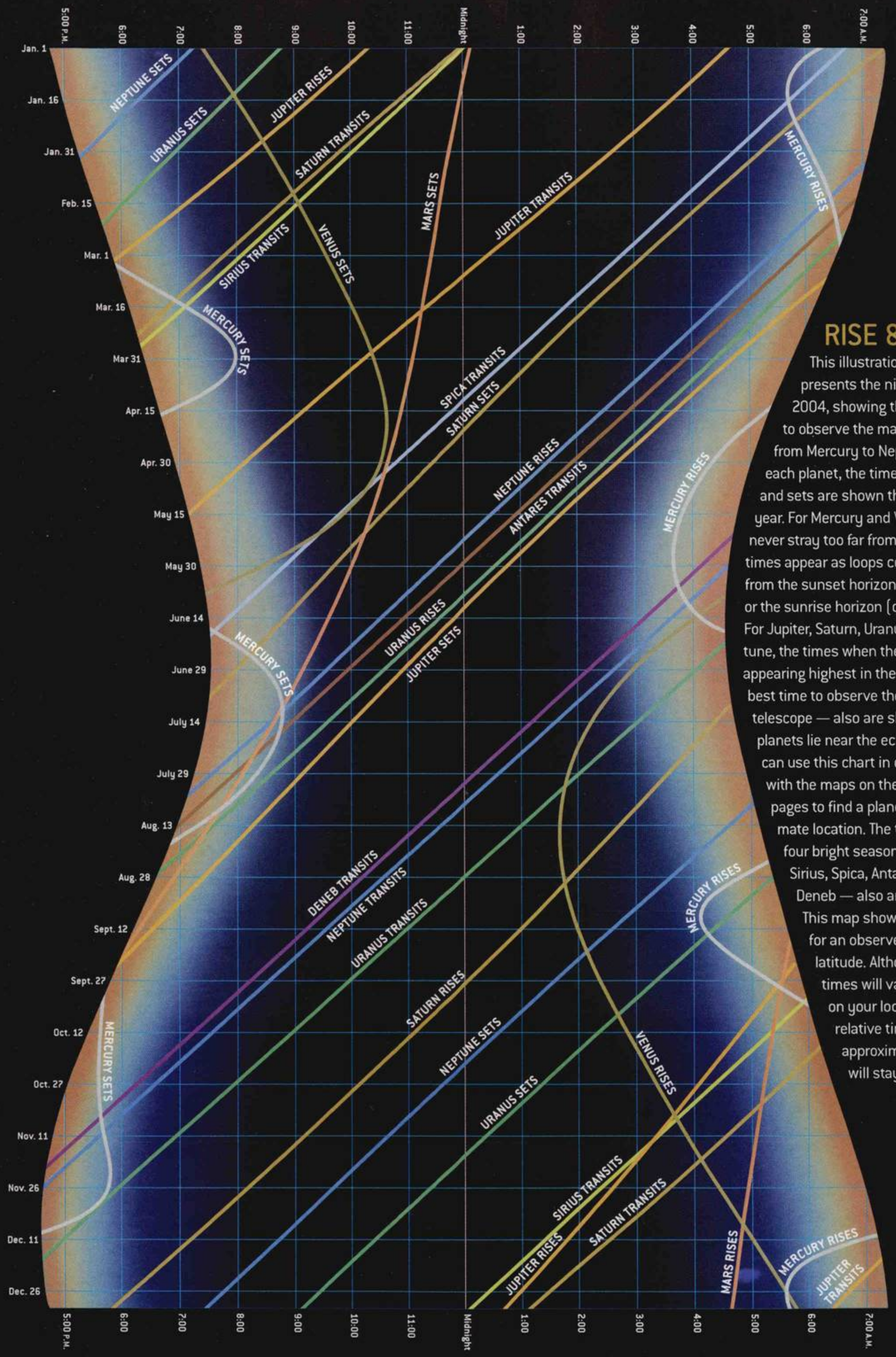
Astronomy's 2004 guide to the night sky



RISE & SET

This illustration graphically presents the night sky for 2004, showing the best times to observe the major planets, from Mercury to Neptune. For each planet, the times when it rises and sets are shown throughout the year. For Mercury and Venus, which never stray too far from the Sun, these times appear as loops coming up from the sunset horizon (on the left) or the sunrise horizon (on the right). For Jupiter, Saturn, Uranus, and Neptune, the times when they transit — appearing highest in the sky and the best time to observe them with a telescope — also are shown. All the planets lie near the ecliptic, so you can use this chart in conjunction with the maps on the previous pages to find a planet's approximate location. The transit times of four bright seasonal stars — Sirius, Spica, Antares, and Deneb — also are included. This map shows local times for an observer at 40° north latitude. Although exact times will vary depending on your location, the relative times and approximate positions will stay the same.

LUNAR PHASES

New	First	Full	Last
		Jan. 7	Jan. 14
Jan. 21	Jan. 29	Feb. 6	Feb. 13
Feb. 20	Feb. 27	Mar. 6	Mar. 13
Mar. 20	Mar. 28	Apr. 5	Apr. 11
Apr. 19	Apr. 27	May 4	May 11
May 19	May 27	June 3	June 9
June 17	June 25	July 2	July 9
July 17	July 24	July 31	Aug. 7
Aug. 15	Aug. 23	Aug. 29	Sept. 6
Sept. 14	Sept. 21	Sept. 28	Oct. 6
Oct. 13	Oct. 20	Oct. 27	Nov. 5
Nov. 12	Nov. 19	Nov. 26	Dec. 4
Dec. 11	Dec. 18	Dec. 26	

All dates are for the eastern time zone. A Full Moon rises at sunset and remains visible all night; a New Moon crosses the sky with the Sun and can't be seen.

NASA

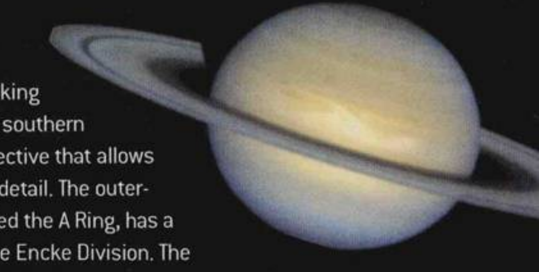
THE MOON is Earth's nearest neighbor and the only celestial object humans have visited. Because of its changing position relative to the Sun and Earth, the Moon appears to go through phases, from a slender crescent to Full Moon. The best time to observe the Moon with a telescope comes a few days on either side of its two quarter phases. For the best detail, look along the terminator — the line separating the sunlit and dark parts.

HST

VENUS puts on a spectacular show throughout 2004. During the first five months of the year, it appears as a brilliant object in the west after sunset. This is the best evening apparition of the brightest planet in a decade. During the final six months of the year, it shines brilliantly in the east before dawn. But the most spectacular event comes between these two periods. On June 8, Venus transits (passes in front of) the face of the Sun for the first time since 1882.

HST

JUPITER'S dynamic face shows an alternating series of dark belts and brighter zones pocked by the Great Red Spot. Even in a small telescope, the planet's four biggest moons — Io, Europa, Ganymede, and Callisto — appear conspicuous. You may see dramatic movement of these bright moons during the course of a single night. Io, closest to Jupiter, orbits the planet in just 1.8 days, while the most distant, Callisto, takes 16.8 days to complete one orbit.



SATURN presents a beautiful view of its rings during 2004. Right now, we are looking down on the planet's southern hemisphere, a perspective that allows us to see lots of ring detail. The outermost bright ring, called the A Ring, has a thin gap known as the Encke Division. The much broader Cassini Division separates the A Ring from the brighter B Ring. The faint C Ring (also called the Crepe Ring) appears inside the B Ring.

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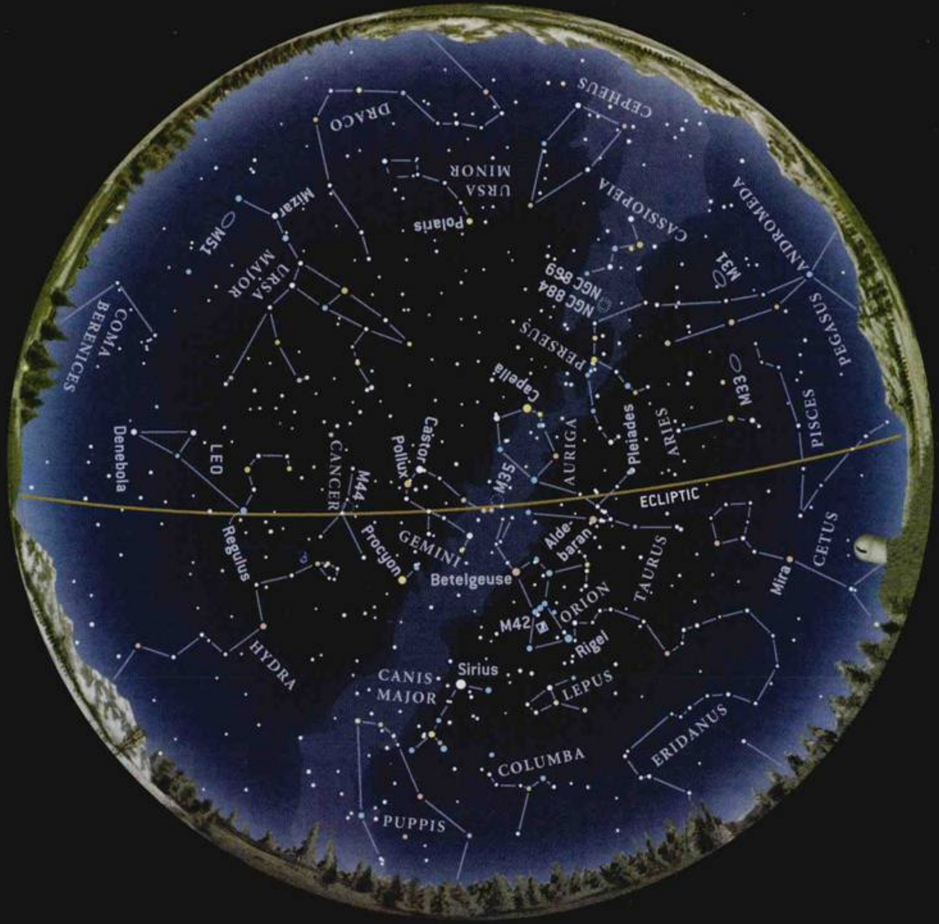
WINTER

The sky

Winter boasts the brightest stars of any season. Orion the Hunter dominates the winter evening sky. Its seven brightest stars form a distinctive hourglass pattern. The bright blue star marking Orion's left foot is Rigel, and the ruddy gem at his right shoulder is Betelgeuse. The three stars of the Hunter's belt point down to Sirius, the brightest star in the night sky, and up to Aldebaran, the eye of Taurus the Bull. Above Orion lies the constellation Gemini the Twins.

Deep-sky highlights

The Pleiades (M45) is the brightest star cluster in the sky. It looks like a small dipper, but it is not the Little Dipper.
The Orion Nebula (M42), a region of active star formation, is one of the showpieces through telescopes of all sizes.
The Rosette Nebula (NGC 2237/9), located 10° east of Betelgeuse, presents an impressive cluster of stars and gaseous nebula.
Castor in Gemini is easy to split into two components with a small telescope, but the system actually consists of six stars.
M37 in Auriga the Charioteer is a pretty open cluster best viewed with a telescope.


DRACO
URSA MINOR
Polaris
CEPHEUS
CASSIOPEIA
ANDROMEDA
M31
NGC 869
NGC 884
URSA MAJOR
Mizar
M51
COMA BERENICES
PERSEUS
Capella
M33
PEGASUS
PISCES
ARIES
Pleiades
AURIGA
M35
Castor
Pollux
CANCER
M44
LEO
Denebola
Regulus
Procyon
GEMINI
ECLIPTIC
Aldebaran
TAURUS
Betelgeuse
M42
ORION
Rigel
Mira
CETUS
HYDRA
CANIS MAJOR
Sirius
LEPUS
ERIDANUS
COLUMBA
PUPPIS

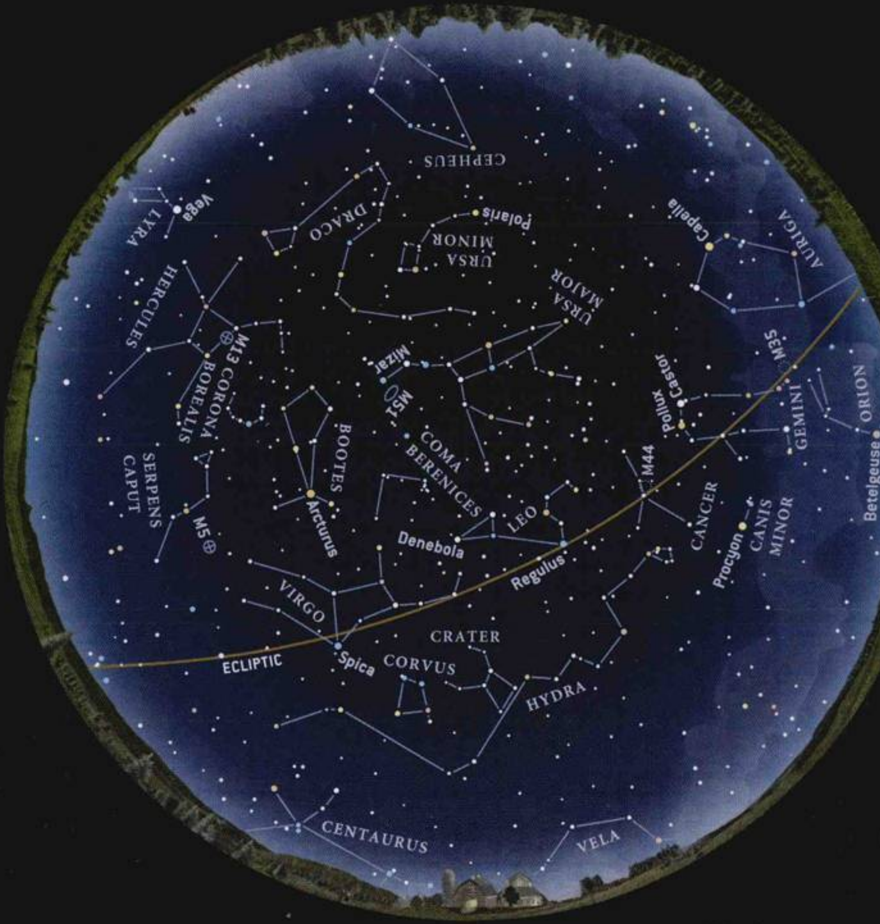
SPRING

The sky

The Big Dipper, the most conspicuous part of the constellation Ursa Major the Great Bear, now rides high in the sky. Poke a hole in the bottom of the Dipper's bowl and the water would fall on the back of Leo the Lion. The two stars at the end of the bowl, called the Pointer Stars, will lead you directly to Polaris, the North Star. From the bowl's top, simply go five times the distance between the Pointers. Spring is the best time of year to observe a multitude of galaxies. Many of these far-flung island universes, containing hundreds of billions of stars, congregate in northern Virgo and Coma Berenices.

Deep-sky highlights

The Beehive Cluster (M44) was used to forecast weather in antiquity. It is a naked-eye object under a clear, dark sky, but it disappears under less optimal conditions.
M3, a conspicuous globular cluster, lies in the obscure constellation Canes Venatici the Hunting Dogs.
The Whirlpool Galaxy (M51) is a vast spiral nearly 40 million light-years away.
M81 and **M82** in Ursa Major form a pair of galaxies that can be spotted through a low-power eyepiece.


CEPHEUS
LYRA
Vega
DRACO
Polaris
URSA MINOR
Capella
AURIGA
URSA MAJOR
HERCULES
M13
CORONA BOREALIS
Mizar
M51
M35
GEMINI
Castor
Pollux
ORION
Betelgeuse
SERPENS CAPUT
M5
Arcturus
BOOTES
COMA BERENICES
M44
CANCER
Procyon
CANIS MINOR
Denebola
LEO
Regulus
VIRGO
Spica
ECLIPTIC
CRATER
CORVUS
HYDRA
CENTAURUS
VELA

2004 EVENTS

March 3 Jupiter is at opposition

March 29 Mercury is at greatest eastern elongation

March 29 Venus is at greatest eastern elongation

April 19 Partial solar eclipse (southern Africa, Antarctica)

April 21 Lyrid meteor shower peaks

May 4 Total lunar eclipse (Europe, Asia, Africa, Australia)

June 8 Venus transits the Sun's disk

June 11 Pluto is at opposition

August 5 Neptune is at opposition

August 12 Perseid meteor shower peaks

August 17 Venus is at greatest western elongation

August 27 Uranus is at opposition

September 9 Mercury is at greatest western elongation

September 13 Asteroid Vesta is at opposition

October 13 Partial solar eclipse (northwestern Asia, Hawaii, western Alaska)

October 21 Orionid meteor shower peaks

October 27 Total lunar eclipse (Americas, Europe, Africa)

November 17 Leonid meteor shower peaks

December 13 Geminid meteor shower peaks

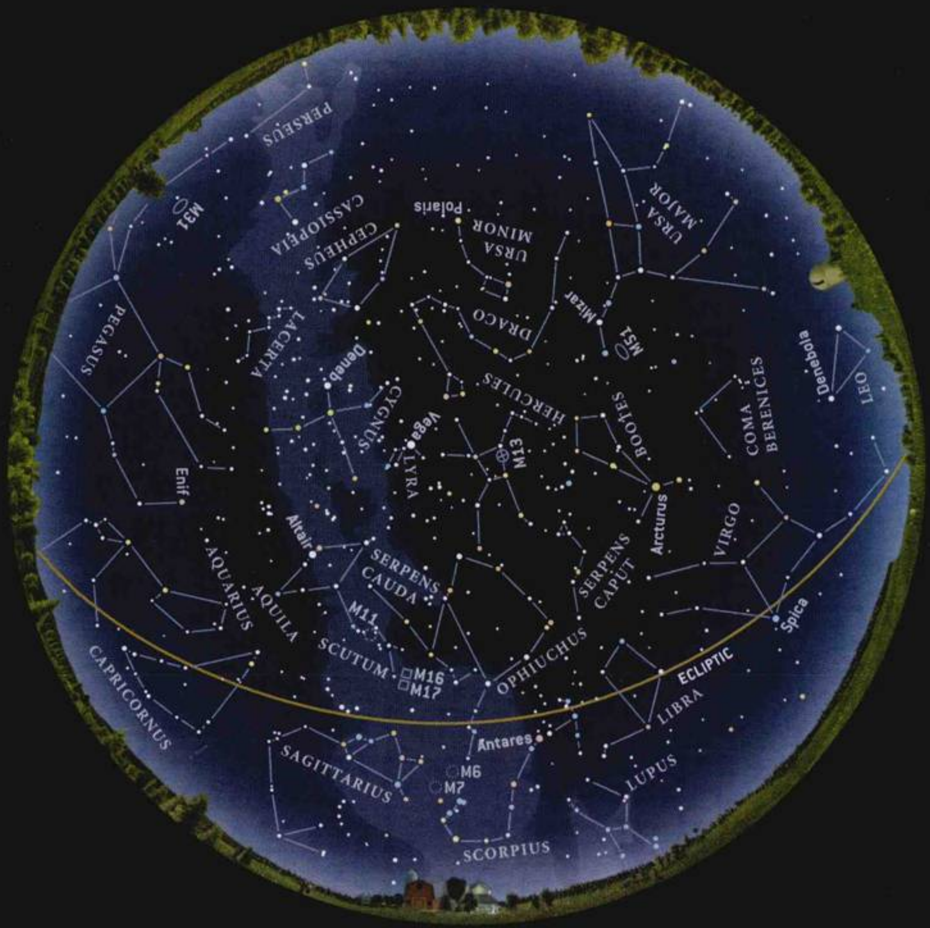
SUMMER

The sky

High in the sky, the three bright stars known as the Summer Triangle are easy to spot. These luminaries — Vega in Lyra, Deneb in Cygnus, and Altair in Aquila — lie near the starry path of the Milky Way. Following the Milky Way south from Cygnus, we find the center of our galaxy in the constellation Sagittarius the Archer. Here, you will find countless star clusters and glowing gas clouds. Just west of Sagittarius lies Scorpius the Scorpion, which contains the red supergiant star Antares as well as M6 and M7, two brilliant clusters that look marvelous at low power.

Deep-sky highlights

The Hercules Cluster (M13) contains nearly a million stars and is the finest globular cluster in the northern sky.
The Ring Nebula (M57) looks like a puff of smoke through a medium-sized telescope.
The Omega Nebula (M17) looks like the Greek letter of its name through a telescope at low power. This nebula also is called the Swan.
The Wild Duck Cluster (M11) is a glorious open star cluster. On a moonless night, a scope will show you more than fifty stars.
The Double-Double (Epsilon Lyrae) can be split into a pair of double stars even with a small telescope.


PERSEUS
M31
CASSIOPEIA
CEPHEUS
Polaris
URSA MINOR
URSA MAJOR
Mizar
M51
DRACO
LACERTA
Deneb
PEGASUS
CYGNUS
Vega
LYRA
HERCULES
M13
BOOTES
COMA BERENICES
Denebola
LEO
Enif
Altair
AQUARIUS
AQUILA
SERPENS CAUDA
M11
SCUTUM
M16
M17
OPHIUCHUS
SERPENS CAPUT
Arcturus
VIRGO
Spica
ECLIPTIC
LIBRA
CAPRICORNUS
Antares
SAGITTARIUS
M6
M7
LUPUS
SCORPIUS

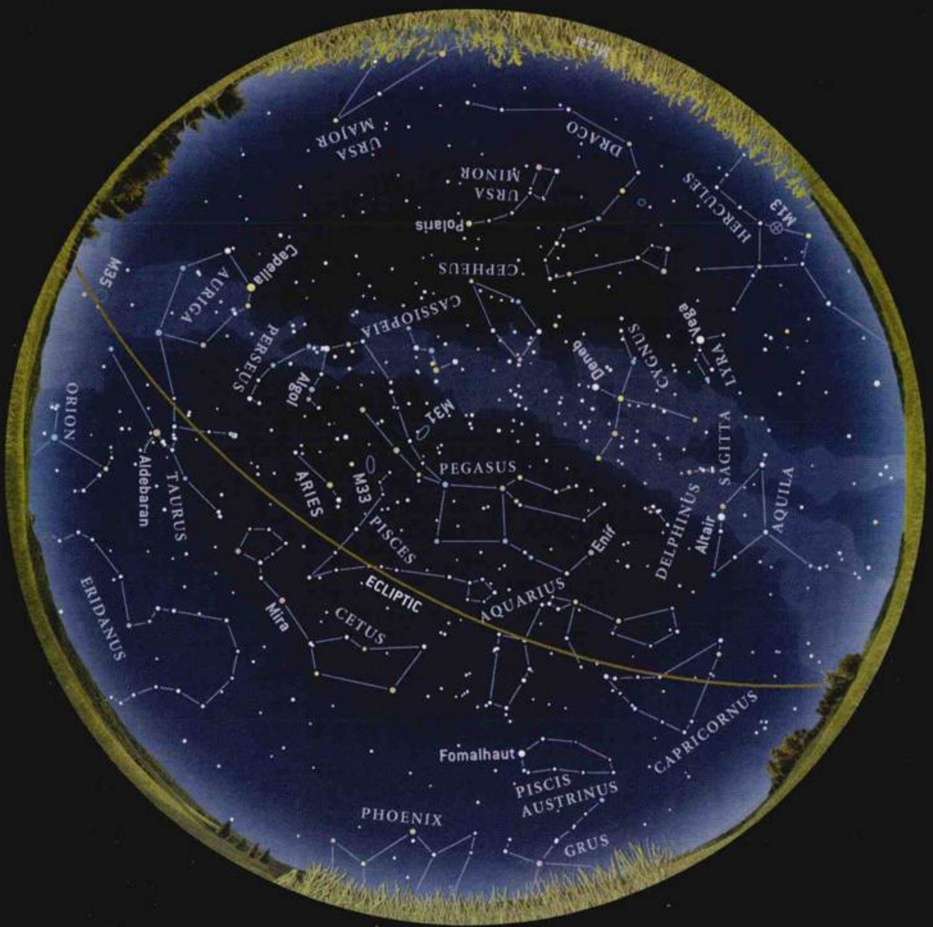
AUTUMN

The sky

The Big Dipper swings low this season, and from parts of the southern United States, it even sets. With the coming of cooler nights, Pegasus the Winged Horse rides high in the sky as the rich summer Milky Way descends in the west. Fomalhaut, a solitary bright star, lies low in the south. The magnificent Andromeda Galaxy (M31) reaches its peak nearly overhead on autumn evenings, as does the famous Double Cluster. Both of these objects appear as fuzzy patches to the naked eye under a dark sky.

Deep-sky highlights

The Andromeda Galaxy (M31) is the brightest naked-eye object outside our own galaxy that is visible in the northern sky.
The Double Cluster (NGC 869 and NGC 884) in Perseus consists of twin open star clusters. It's a great sight through binoculars.
M15 in Pegasus is a globular cluster containing hundreds of thousands of stars, many of which can be glimpsed with a medium-sized telescope.
Albireo (Beta Cygni), the most beautiful double star in the sky, is made up of stars colored sapphire and gold.


URSA MAJOR
DRACO
URSA MINOR
Polaris
HERCULES
M13
M35
CEPHEUS
Capella
AURIGA
CASSIOPEIA
Deneb
Vega
LYRA
CYGNUS
PERSEUS
Algol
M31
ORION
Aldebaran
TAURUS
ARIES
M33
PISCES
PEGASUS
SAGITTA
DELPHINUS
Altair
AQUILA
Enif
ECLIPTIC
ERIDANUS
Mira
CETUS
AQUARIUS
CAPRICORNUS
Fomalhaut
PISCIS AUSTRINUS
PHOENIX
GRUS

THE DEEP SKY

Queen Cassiopeia's jewel box is so deep, it's worth seeking out the treasures in the corners.

The W doubles as an M

Thanks to the prominent W shape of its brightest stars, Cassiopeia ranks among the first few constellations that backyard skygazers learn. By winter, however, when you face north and look up, Cassiopeia has rotated around the north pole star so it looks like an M.

The top left star of the M is Alpha (α), the brightest. If you slide toward the middle star of the M, you'll hit Eta (η), a lovely binary star discovered by Sir William Herschel. Low power splits the pair, but 100x or higher frames them nicely. The brighter component shines yellow while the fainter companion takes on different hues depending on the observer's perception. Most say it's orange, but some see a pale garnet or even purple.

Nearby lies the quadruple star B1, the core of emission nebula NGC 281. Instead of hunting it down, let Earth do the work for you. Set your scope on Alpha (with the drive off), then come back to the eyepiece twelve minutes later, when Earth has rotated the system into view. Unless you push the power up to 200x or so, you'll see only one star. Keep cranking though, because the fourth star is a scant 1.5" east of the brightest and two magnitudes fainter.

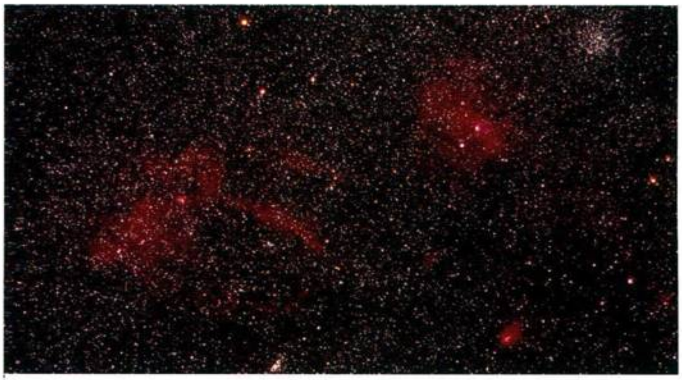
Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist with Environment Canada.*

Jump in a straight line from Alpha through its neighbor, Beta (β), to land on M52, a modestly rich star cluster visible from the city. At low power, skyglow often suppresses the fainter members, so use about 100x to get a nice view. The French observer and comet hunter Charles Messier discovered this group on September 7, 1774, as he was following a bright comet.

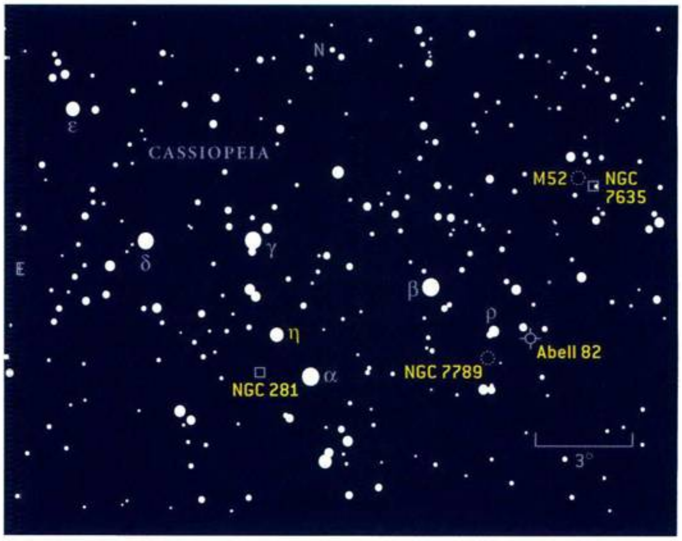
Treasures in the dark

Using a bigger telescope than Messier from a darker site, William Herschel found the Bubble Nebula only one lunar diameter west of M52 on November 3, 1787. Later recataloged as NGC 7635, this tenuous gas cloud is not easy to spot with an 8-inch scope. Do your sky watching midmonth, when the glare of the Moon has left the evening sky. A nebula filter will help considerably, and don't forget to try different magnifications.

Also called a light-pollution-rejection (LPR) filter, this accessory lets you see the large Pac-Man Nebula, NGC 281. The nebula surrounds the quadruple star B1 we visited earlier. You can see the glow even with binoculars if you hold the filter between your eye and one of the eyepieces.



STAR CLUSTER M52 (NGC 7654) shares space in Cassiopeia with several stunning emission nebulae. GEORGE GREANEY



With binoculars, a most delightful sight from country skies is the open cluster NGC 7789, located 3° southwest of Beta Cassiopeiae. Discovered by Caroline Herschel, this Moon-sized glow transforms into dozens of stars when seen through a small telescope. More aperture makes the view better, revealing several hundred points of diamond dust.

If you own a 10-inch or larger scope and feel up to a challenge, hop 1.5° west to Abell 82, a large but faint planetary nebula. The puffed out remnants of a dying star, this circular gas cloud is a ghostly version of the Ring Nebula (M57). Invisible without a nebula filter, Abell 82 is best seen through a specialized OIII filter. If you're a dedicated nebula hound, the OIII is a "must have" accessory.

Dozens more star clusters and diffuse and planetary nebulae inhabit the Milky Way in Cassiopeia. It's best to use an atlas to navigate the queen's crowded coffer.

THE PLANETS

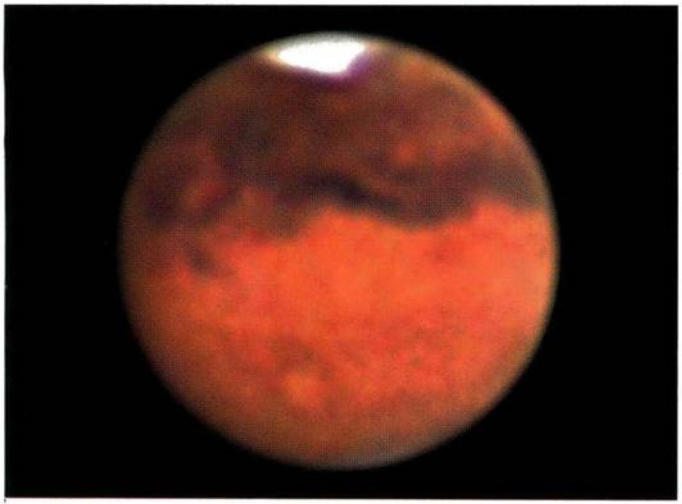
Although Venus dominates the early evening sky, Saturn rules the night from late evening until dawn.

THE RINGED PLANET shines bright and remains visible nearly all night long this month. SUBARU TELESCOPE/NAOJ

Venus dominates the western sky after sunset. As it sets late in the evening, it cedes the stage to the wonderful Ringed Planet, Saturn, rising above the eastern horizon. Saturn is the king of the night this month. Uranus and Neptune can be spotted briefly, also in the western sky, while Mars stands high above Venus.

Brilliant **Venus** lies in Capricornus the Sea Goat, where it shines at magnitude –4.0. Through a telescope, its small disk appears slightly more than 80 percent illuminated in early January. The phase shrinks slowly during January while the apparent size of the disk increases. On January 31, the disk spans 15" with a three-quarters-lit phase.

Venus stands little more than 1° northwest of Delta (δ) Capricorni, Deneb Algiedi, on January 9. The current easterly path of Venus takes it within 1° of Uranus on January 14. You'll need binoculars and a good star chart to spot Uranus. The seventh planet lies slightly southwest of 38 Aquarii, a 5.4-magnitude star marked on many star charts.



MARS was at its best last August. (14-inch Meade Schmidt-Cassegrain telescope at f/20, Pictor 416xte CCD camera, August 19, 2003) JOE PETRICK

Binocular viewers may notice that Venus has gained a moon on January 28. However, the bright object to the lower right of Venus is the 4.3-magnitude star Phi (ϕ) Aquarii. The star stands 8' west of Venus as soon as the sky darkens, and the gap slowly increases until Venus sets just before 10 P.M. local time.

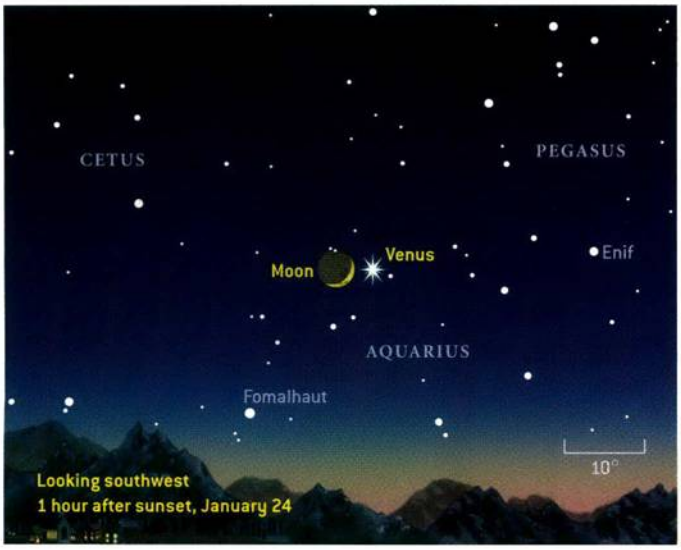
Watch for the spectacular wintertime pairing of the crescent Moon and Venus on January 24. On this North American evening, Venus stands 4.2° northwest of the three-day-old Moon.

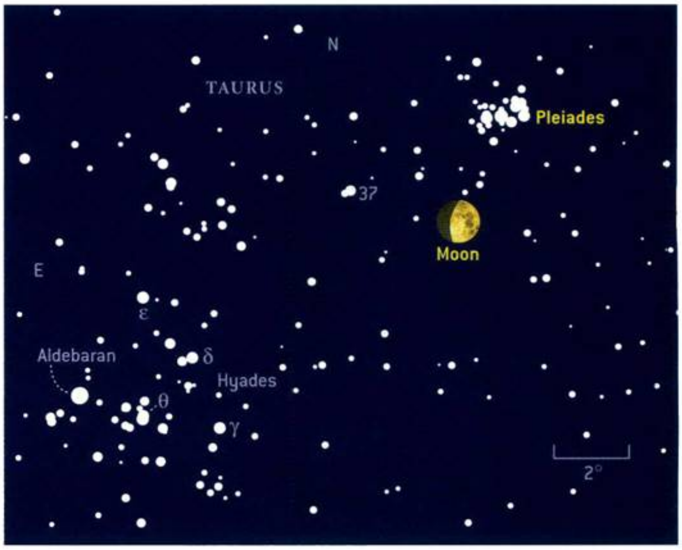
High above Venus, among the stars of Pisces the Fish, **Mars** glows with a ruddy hue at magnitude 0.2. You'll need a large telescope — 12 inches in diameter or larger — to have an easy time viewing details on Mars's tiny, 8"-diameter disk.

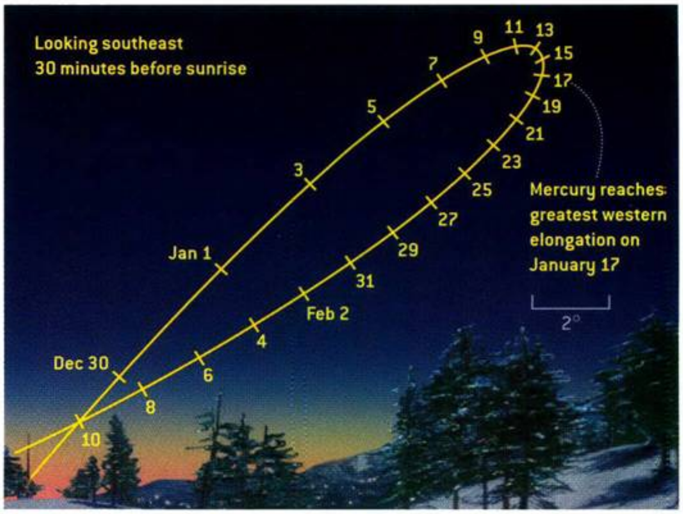
During December and January, much interest will be on the spacecraft approaching Mars. The British Beagle 2 is expected to land in late December. The two American rovers, Spirit and Opportunity, are due to land a few weeks apart during January. As both craft return images, remember to step outside and see the Red Planet in the night sky.

Throughout January, Mars transits the constellation Pisces. The planet is joined there by the First Quarter Moon on January 27, when you'll find Mars standing 3° above the Moon. Mars sets about 1 A.M. local time.

Following its near encounter with Mars, the


CETUS
PEGASUS
Moon
Venus
Enif
AQUARIUS
Fomalhaut
10°
Looking southwest
1 hour after sunset, January 24


N
TAURUS
Pleiades
37
Moon
E
ε
Aldebaran
δ
Hyades
θ
γ
2°


Looking southeast
30 minutes before sunrise
9
11
13
15
17
19
21
23
25
27
29
31
7
5
3
Jan 1
Dec 30
10
8
6
4
Feb 2
Mercury reaches greatest western elongation on January 17
2°

Moon passes into Taurus the Bull. On the next evening, North American observers will see the Moon lying 3° south of M45, the Pleiades star cluster.

On January 6, the Moon rises with **Saturn** nearby. Catch the Moon right after sunset just above the eastern horizon; look to a point 4° (eight Moon-widths) to its right to spot Saturn as it rises. By 8 P.M. local time, Saturn is an unmistakable bright object in Gemini. It is joined by the brilliant stars of Orion to its southwest. Saturn remains visible, shining at magnitude –0.4, all night and every night throughout January. (See "Saturn in prime time" on page 88 for more details.)

Don't be disappointed by the view of Saturn just after it rises. Most observers recognize that better viewing begins at least an hour after the planet rises and continues to improve as it climbs higher in the sky, clearing the worst turbulence in our atmosphere.

Saturn passes almost overhead at midnight local time, so use a star diagonal for comfortable views and settle back for some spectacular sights.

By mid-January, the Moon is out of the way, passing into the morning sky and leaving Saturn to rise in a dark sky. It's a spectacular object set against the backdrop of winter stars. Saturn's retrograde motion continues but slows this month as the planet moves westward toward the pair of stars in the northwestern corner of Gemini, Mu (μ), and Eta (η) Geminorum.

Jupiter lies near the hind legs of Leo the Lion. It rises around 10:30 P.M. in early January. Shining at magnitude –2.3, it is the brightest starlike object in the sky, rising after Venus has set. Jupiter rises with a waning gibbous Moon on January 12, standing less than 5° below our satellite.

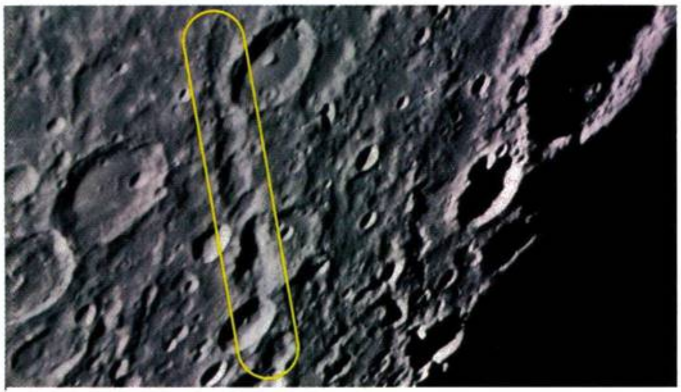
Jupiter's own moons are viewed edge-on, resulting in many occultations, eclipses, and transits. In addition to events including Io, Europa, and Ganymede, Callisto currently is undergoing a series of rare eclipses, occultations, and transits. Small telescopes can show you these events with ease (see their timing on the next page).

Mercury makes a brief appearance in the early morning sky during the middle two weeks of January. It hovers low in the southeast at least an hour before sunrise. Mercury, shining at magnitude –0.2, stands 9° northeast (left) of the crescent Moon on January 19. Compare the planet to the twinkling star Antares, higher in the sky to the south. The crescent Moon lies near Antares, in Scorpius, the previous morning. To the south of Mercury lies the star at the top of the Teapot asterism in Sagittarius, Lambda (λ) Sagittarii. The oncoming twilight allows for only brief viewing of the star.

Our own planet, **Earth**, reaches perihelion, its nearest point to the Sun, on January 4. We then stand 0.983 astronomical unit away from the Sun (91.4 million miles).

METEORS AND MOONS

While the outer Galilean moon plays tag with the disk of Jupiter, a prominent valley on Earth's Moon comes to the fore just after Full Moon.



THE DEEP RHEITA VALLEY (oval) lies in the southern highlands of the Moon, just off the shore of Mare Nectaris. FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)

Quadrantid meteors

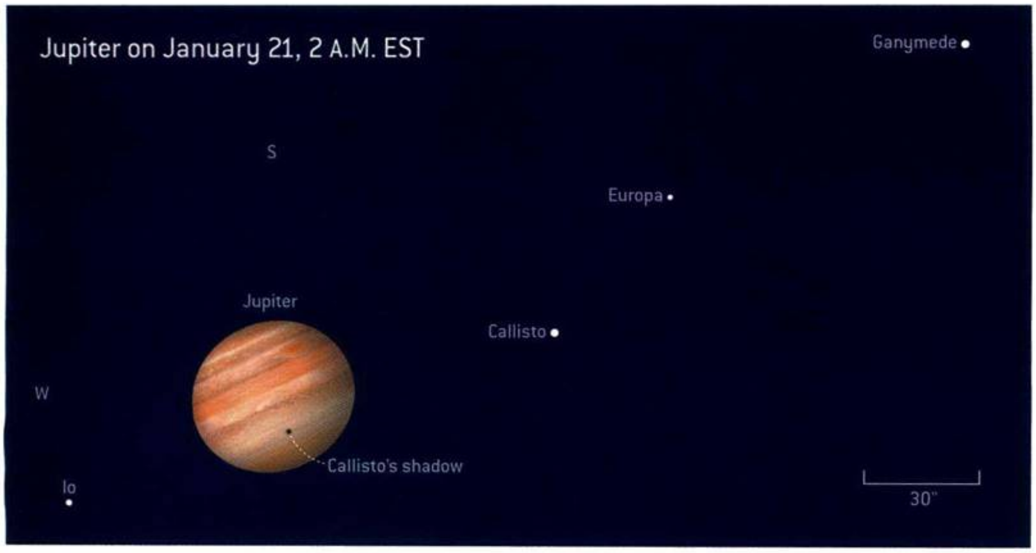
This annual shower is active from January 1 through 5, peaking on the 4th at 1 A.M. EST. With the Moon just three days from full phase, not many meteors will be visible. Try listening to a distant FM radio station. The telltale whisper of meteors can be detected as they cause brief ionization trails in the atmosphere where radio waves bounce. It's a way to "observe" meteors from the comfort of a warm room.

Moon feature: Rheita Valley

Nestled in the southeastern lunar highlands, the Vallis Rheita, or Rheita Valley, is an obvious feature. It lies next to the giant, ancient crater Janssen. The valley is 112 miles long and 15 miles wide. The 43-mile-wide crater Rheita sits at the lower end of the valley, sporting a clear central peak and flat crater floor. The valley may have been formed from impact debris hurled out when nearby Mare Nectaris was formed, a theory supported by its position near Nectaris. The valley is actually more aligned with Mare Imbrium, though, which some theories identify as the culprit. Whatever the cause, the valley appears to be a chain of craters splashed across an ancient terrain. View this complex region a few days after the January 7 Full Moon.

Jupiter's satellites

Rare occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue. During each 12-year orbit of Jupiter around the Sun, only two series of eclipses involving Callisto occur. The current series began in late 2001 and continues until September 2004. During this time, only sixty-six eclipses will occur. The events listed in the table below are given in both Universal Time and Eastern Standard Time. Events that occur on either side of midnight are shown twice because the date changes for observers in Europe or the United States. Tr = transit; I = ingress; E = egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their relative rarity. Not all events are visible from the United States.



/// JANUARY CALLISTO EVENTS

	{ UT }	{ EST }	{ Event }
4th	11h01m	6:01	Sh.I.
	14h56m	9:56	Sh.E.
	21h57m	16:57	Tr.I.
		19:51	Tr.E.*
5th	00h51m		Tr.E.*
12th	19h27m	14:27	Ec.D.
	23h23m	18:23	Ec.R.
13th	05h53m	0:53	Oc.D.
	08h40m	3:40	Oc.R.
20th		23:59	Sh.I.*
21st	04h59m		Sh.I.*
	08h48m	3:48	Sh.E.
	14h00m	9:00	Tr.I.
	16h43m	11:43	Tr.E.
29th	13h28m	8:28	Ec.D.
	17h17m	12:17	Ec.R.
	21h25m	16:25	Oc.D.
		19:04	Oc.R.*
30th	00h04m		Oc.R.*

*Events that occur on either side of midnight are shown twice.

COMETS AND ASTEROIDS

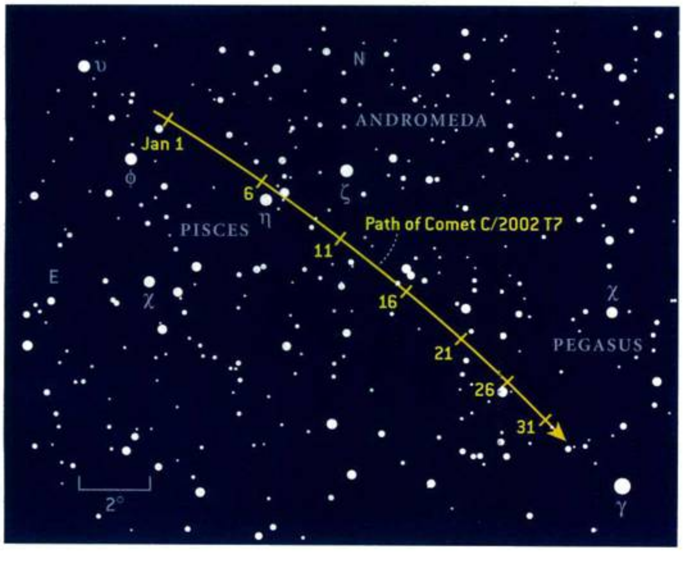
Comet C/2002 T7 (LINEAR) brightens significantly as it prepares for its springtime show, while the largest asteroid rocks Gemini.

A binocular comet

Backyard observers eagerly anticipate the spring comet show. Two dirty snowballs with nice long tails should grace our skies at 1st or 2nd magnitude, one in the morning and one in the evening.

The best comet this month should be C/2002 T7 (LINEAR), discovered on October 14, 2002, by the robotic Lincoln Laboratory Near-Earth Asteroid Research project telescope. Comets often are called primordial because they formed during the birth of the solar system some 4.5 billion years ago and still contain molecules that were part of our solar system's birth cocoon.

If C/2002 T7 continues to brighten as expected, it should rise from 8th to 7th magnitude as it crosses the evening sky high in the south below Andromeda, to the left of the Great Square of Pegasus. Use the time from January 10 to 24, when the Moon's interfering glow is out of the evening sky, to view the comet. Even from a suburban backyard, the comet should be visible as a small, roundish cloud through a 4-inch scope. As with deep-sky objects, a fuzzy comet needs dark skies to be seen at its best. Because C/2002 T7 is similar in brightness to many Messier galaxies, you should be able to spot it with binoculars. Don't forget to look for the nearby Pinwheel Galaxy (M33) in Triangulum.

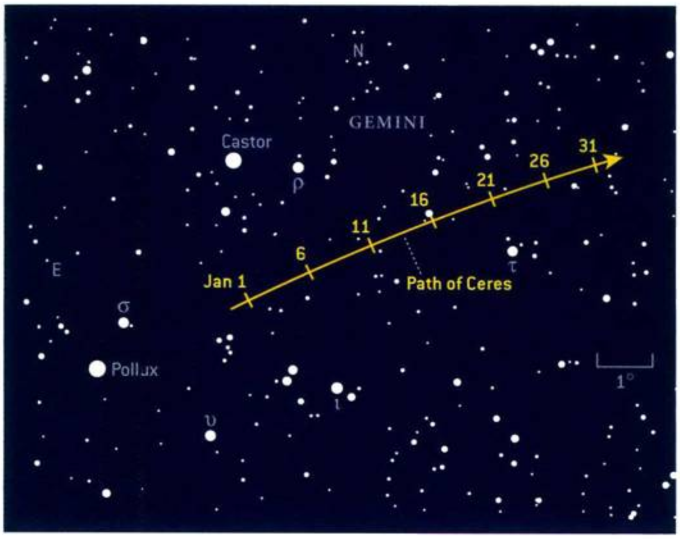


Could C/2002 T7 be just a frosty fake? It's happened before to some comets on their first visit to the inner solar system. When a fresh comet's shallow layer of frost first heats up, it reflects a lot of sunlight. But once it evaporates, the dirty snowball that remains is much fainter, and the comet's brightness can plunge by a factor of fifty or more. This happened to the infamous comet Kohoutek in the 1970s. Cross your fingers that C/2002 T7 will be a real performer like Hale-Bopp was a few years ago.

/// COMET POSITIONS

COMET C/2002 T7 (LINEAR)

{Date}	{R.A.}	{Dec.}
Jan. 1	1h09.2m	25°45'
Jan. 6	0h57.8m	23°57'
Jan. 11	0h48.1m	22°17'
Jan. 16	0h40.0m	20°46'
Jan. 21	0h33.2m	19°23'
Jan. 26	0h27.6m	18°10'
Jan. 31	0h22.9m	17°04'



Castor's stone

Gliding through the silence of space, the 560-mile-wide (900 km) minor planet 1 Ceres is visible through binoculars as it cruises in front of the stars of Gemini. It remains within one field of view of the double star Castor the whole month. To keep straight which twin is which, remember the mnemonic: Castor is closer to Capella, and Pollux is on the same side as Procyon.

Use the finder chart to skip your way along stars of similar brightness to Ceres. After a couple nights, you'll be able to tell which "star" moved, especially if you make a quick sketch of their initial positions, and you will have located Ceres.

On the night of January 16, a telescope will show you the 6.9-magnitude Ceres moving westward relative to a 6.2-magnitude background star over the course of just a couple hours.

While you're in the neighborhood, swing your scope onto Castor and punch up the power to 150x. Doing so will split this famous double into its two components, which are located just 4" apart. ■

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#773, #774, #775 ,#776 Hard Case for ETX	CALL

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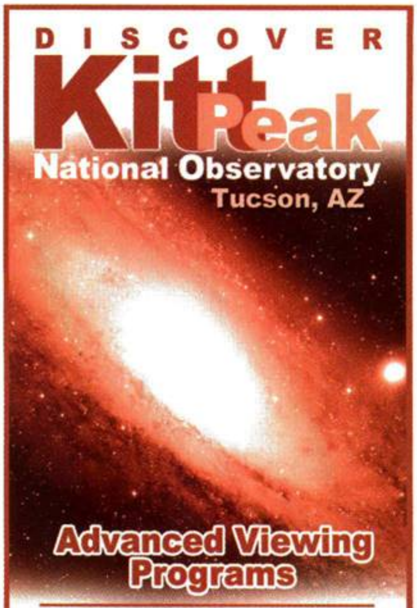

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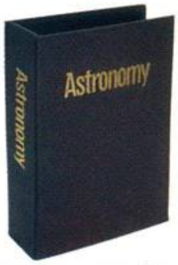

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ASK ASTRO

Turning stars on, Tycho and Galileo, orbits

TURNING STARS ON

If a star "ignites" on reaching a critical mass, why do stars vary so greatly in size?

— **NORM MURRAY,** GOLDEN, COLORADO

CLOUDS OF DUST AND GAS, such as the Horsehead Nebula in Orion, contain stars that have a variety of sizes. Each star's diameter depends on its mass. ESO

Stars range from the size of Manhattan to the orbits of planets. A star does not "ignite" when it reaches a critical mass, but when its central core reaches a critical temperature and density. Mass, age, and stage of evolution all contribute to a star's size.

Stars form through the gravitational contraction of dense knots of interstellar matter. As gravity squeezes one of these knots, its interior heats up, much like the air-fuel mixture in a diesel engine. When the central core of a knot (of whatever mass) hits a temperature of about 8 million kelvins (14 million degrees Fahrenheit), the hydrogen, which constitutes 90 percent of the atoms in the gas, ignites.

The ignition is not a chemical reaction like in a car engine — it's the initiation of nuclear fusion. This is the process in which hydrogen converts into helium with a slight loss of mass and the subsequent creation of energy (via Einstein's equation $E = mc^2$, where E is energy, m is the mass lost, and c is the speed of light).

The onset of nuclear fusion creates a counterbalancing pressure that stops the contraction of the knot, and the new star stabilizes at a radius that depends mostly on its initial mass. The greater the mass, the more luminous and larger the star. The maximum mass seems to be around 100 to 120 solar masses. If a star more massive than this should form, it would be ultraluminous, shining a million times brighter than the Sun, and would tear itself apart by the pressure of its own powerful radiation.

The lower limit of a real star is 0.08 solar mass. Below this limit, the central pressure — and therefore temperature — is too low to ignite the gas. Objects of about this mass become substars called brown dwarfs. The lower limit of brown dwarfs is still unknown, and it might even reach into the realm of planetary masses.

Hydrogen-fusing stars range in diameter from a few times that of Earth to ten or more times that of the Sun. When a star's hydrogen fuel runs out, gravity (along with fusion involving other elements) takes over to help produce stellar energy. The energy released then makes the star temporarily much brighter and larger, creating a giant or a supergiant. Giant stars, which can have diameters the size of the orbit of Mars or greater, lose their outer envelopes by strong stellar winds, while their old cores shrink into dense white dwarfs the size of Earth. Supergiant stars, which can approach the diameter of the orbit of Saturn, eventually explode, their ultradense cores becoming neutron stars the size of a small town or even black holes a couple miles across. — **JIM KALER,** UNIVERSITY OF ILLINOIS

ONLY TWO ASTRONOMERS are widely known by their first names — Galileo Galilei and Tycho Brahe, seen here in effigy on his tombstone in Prague. DAN FALK

TYCHO AND GALILEO

Why are Galileo Galilei and Tycho Brahe so often referred to by their first names? No other astronomer is spoken of in that way. — **PETER LUND,** WHITEFISH, MONTANA

I can only speculate on the first-name usage of Galileo and Tycho, which I think is different in the two cases and, perhaps, largely accidental. As a first point, both names are quite distinctive, which probably has something to do with it. Nobody would know who you meant if you referred to Kepler as "Johannes" or Copernicus as "Nicolaus."

In addition, we think of a number of distinguished Italians simply by their first names — Dante, Michelangelo, and Leonardo come to mind. Galileo lived in a later century, however, and I believe that having essentially the same first and last name must contribute to the usage.

In his book *Astronomia Nova* (1609), Kepler uses "Tycho" and "Brahe" almost interchangeably when referring to his mentor but with a preponderance for Tycho, especially using it as an adjective. Also, societies in which patronymics were common (for example, Tyge Brahe Ottesen, Tycho's full Danish name) may have referred to people more often by their given names. How that led Brahe to become "Tycho" to the European scholarly community at large, however, remains a bit puzzling. — **OWEN GINGERICH,** HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

ORBITING ASTRONAUTS, spacecraft, and planets all obey Kepler's laws of motion. The laws decree that if you want to shift into a faster orbit, you must first lose some speed. NASA

ORBITS

If an astronaut increases orbital speed, does this ultimately result in a slower orbital speed? Likewise, if orbital speed slows, does this make a faster orbital speed? — **RICHARD SNYDER,** SILVER CITY, NEW MEXICO

It borders on paradox, but the quick answer to both your questions is — yes. But to see why this is so, we must delve into the basic principles of orbital mechanics as given in Kepler's three laws of planetary motion. We can ignore laws one and three, but the second law relates directly to your question.

It says that in a stable orbit, the area swept by an imaginary line connecting the orbiting body to its parent body remains constant for a given interval of time — no matter where the object is in its orbit.

To see what this means, let's use Comet Halley as an example. The comet's highly elliptical orbit carries it around the Sun once every 76 years. When it passes closest to the Sun, it travels very fast, and the line between it and the Sun sweeps a certain area in a given interval of time. Half an orbital period later, when the comet lies farthest from the Sun, it's barely moving in its orbit — but the area swept by the line between it and the Sun still covers the same area in the same amount of time.

Adding energy by firing a rocket to boost you in the direction of flight has the effect of lengthening the line. You gain speed as long as the rocket is firing, but as soon as you cut it off, gravity starts robbing you of velocity. Depending on how much gas you've hosed out, you'll reach a point where gravity overcomes the energy from the rocket firing. This is called apogee — the point farthest from Earth — if you're orbiting Earth.

At apogee, a spacecraft will start to coast back down to the perigee point (closest to Earth), gaining speed as it goes. It passes through perigee at maximum orbital speed, then heads back out again to apogee, slowing as it goes.

Round and round your spacecraft goes, following the same elliptical path until you apply the next change of energy. Kepler's laws still rule, so when you're close to Earth, the line between you and Earth must sweep out a large arc to make up for the shortened radial distance. Out near apogee, where that line extends farther, you don't need to cover as long an arc to sweep an equal area. — **GEOFF CHESTER,** U.S. NAVAL OBSERVATORY

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Whether it's a telescope, an eyepiece, or a photographic or visual accessory, if it's from TeleVue, chances are good we have it in stock.

Here is a *partial* listing of some of the TeleVue refractors we carry in stock for immediate shipment.

Ranger, 2.7" f/6.8 semi-apo	$\$760^{00}$
Pronto, 2.7" f/6.8 semi-apo	1120^{00}
TV-76, 3" f/6.3 apo	1675^{00}
TV-85, 3.35" f/7 apo	2080^{00}
TV-102, 4" f/8.6 apo	2635^{00}
Renaissance 102, 4" f/8.6 brass apo	3175^{00}
NP-101, 4" f/5.4 apo	3595^{00}

All of the above scopes come without a mount, but include an eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a tube ring for mounting, and a case. Basic optical tubes, without these accessories, are also available.

As for accessories, whether it's a Gibraltar, Panoramic, or Tele-Pod mount; a Sky Tour computer; a Nagler, Radian, Panoptic, or Plössl eyepiece; a Powermate or Barlow; an Everbrite 99% reflectivity diagonal; a BinoVue; a light pollution filter – we have it all.

Others may say they carry TeleVue, *but we actually keep TeleVue in stock.* Call us and see.

The Takahashi premium apo optics sale ends 12/31!

FSQ-106N, $3475.
EM-2S mount,
$2229.

While many people swear *at* the one to three year delivery schedule quoted by some premium refractor makers, most experienced astronomers swear *by* the unsurpassed optics and fast delivery of the *apochromatic* **Takahashi** refractors we keep in stock.

Even better than fast delivery is the special sale pricing on Takahashi apo optical tubes that's scheduled to end 12/31/03. You can save as much as $2334 if you act now!

The 3.1" **FS-78** fluorite doublet optical tube is on sale for **$1195!** It's regularly $1379, so you save $184!

Takahashi's unique 90mm f/5.6 **Sky 90 II** is on sale for **$1849!** Regularly $2279, you save $430! With dew shield retracted, this fluorite apo is less than 14" long! *Sky & Telescope* called it "an ideal travelscope for mobile observers, providing maximum performance at minimum size."

The best-selling 4" **FS-102** fluorite doublet optical tube is on sale for **only $1895**! Regularly $2349, you save over $450!

The 5" **FS-128** fluorite doublet optical tube is **only $4495**! Regularly $5249, you save over $750!

Finally, the big 6" **FS-152** fluorite doublet optical tube is on sale for **only $6995**! Regularly $9329, you save $2334!

We also stock the 22" long Takahashi **FSQ-106N** 4-element f/5 4" *dual fluorite* 4" focuser astrograph apo refractor OTA, shown above on an optional premium Takahashi mount.

If you want a truly first-class apo refractor at a money-saving sale price, and you want it without a lo-o-o-ng wait, the refractor you want is a Takahashi from ***astronomics***.

Our free info pack helps you pick the right Celestron, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, or Vixen scope.

For the most detailed and fully illustrated information on the individual products we carry (including an inventory status that is updated daily), visit our website at **www.astronomics.com**. Or you can get our *free* pricing and information package AST by calling (800) 422-7876 or sending an e-mail to **questions@astronomics.com**.

Our package AST includes our 8-page guide on how to pick the right telescope and our 16-page discount price list that covers the 2000+ *products* that we carry – from companies like Antares, Astrozap, Canon, Celestron, Coronado, Cyanogen Software, Discovery, Fujinon, JMI, Leica, Losmandy, Lumicon, Meade, Minox, Miyauchi, Nikon, Parallax, Pentax, Questar, Rigel Systems, SBIG, Sirius Optics, Software Bisque, Starbound, Starlight Instruments, Stellarvue, Swarovski, Swift, Takahashi, TeleVue, Thousand Oaks, TMB, Vernonscope, Vixen, Zeiss, and more. (Sorry, U. S. sales only.)

The information is yours for only the time it takes to make a free phone call. The information and pricing we send will make it the most useful minute you'll ever invest in astronomy.

Prices and specifications in this ad are current as of 10/10/03, but are subject to change.

Vixen scopes and mounts are in stock.

$2200
Vixen VE102SG
4" f/9 ED apo refractor
(w/optional drive)

Not only telescopes and mounts, but the complete range of Vixen accessories as well – Lanthanum long eye relief and wide angle long eye relief eyepieces, camera adapters, filters, focal reducers, Barlows, and more. Whether it's a telescope, mount, or accessory, if it's from Vixen, chances are good we have it in stock.

Here's a *partial* list of the complete Vixen scopes we had in stock as this was written:

V102MG, 4" achromat, GP mount	$\$1350^{00}$
VE80SG, 3.1" ED apo, GP mount	1655^{00}
VE102SG, 4" ED apo, GP mount	2200^{00}
VF80SG, 3.1" fluorite apo, GP mount	2280^{00}
VF102SG, 4" fluorite apo, GP mount	2900^{00}
VR200G, 8" f/4 reflector, GP mount	1700^{00}

If you want a Vixen optical tube only, we stock their achromats, fluorite apos, ED glass apos, and dual ED glass apo refractors. We also stock Vixen's reflector and catadioptric optical tubes, and the well-known and highly-rated Vixen Great Polaris and Great Polaris DX German equatorial mounts to use with your own optics.

Check our website for a complete listing and current inventory of the Vixen products we keep in stock. If you prefer, you can call us toll-free at (800) 422-7876 to see for yourself.

Discovery Dobs are not cheap . . . just inexpensive.

8" f/6 DHQ
$449

Why settle for an imported Dobsonian with so-so mass-produced optics when premium made-in-the-USA quality costs no more? Discovery's optics are made to diffraction-limited standards by experienced optical craftsmen in California, one high quality mirror at a time. The 6" to 13.1" Discovery DHQ Dobsonians have an open back metal mirror cell for fast cool-down, a thin vane diagonal spider, *two* 1.25" Plössl eyepieces, 2" metal rack and pinion focuser with 1.25" adapter, a built-in tube balancing system, tube carry handle, oversized bearings, 6 x 30mm finder, and tube end dust cover.

Here are the prices for the fully-equipped Discovery DHQ Dobsonians. Freight from the factory in California is additional, as shown.

6" f/8 Discovery DHQ	339^{00}	+ $49 freight
8" f/6 or f/7 Discovery DHQ	449^{00}	+ $49 freight
10" f/4.5 Discovery DHQ	649^{00}	+ $69 freight
10" f/5.6 Discovery DHQ	649^{00}	+ $69 freight
13.1" f/4.5 Discovery DHQ	999^{00}	+ $185 freight

SBIG CCD cameras? We had 60 when this was written.

We had 60 $1995 to $6995 SBIG cameras in stock as this was written. Why so many? We think it's important to keep products in stock so you can get what you want, when you want it, without having to wait for a dealer to special order a product he doesn't stock. Is an inventory of 60 SBIG CCD cameras too many? We think our customers deserve nothing less.

astronomics

Our 25th year of friendly service, good advice, and money-saving prices.

680 SW 24th Avenue, Norman, OK 73069

Toll-Free Order/Catalogs/Questions Line: **(800) 422-7876** Other calls: **(405) 364-0858**

We'll sell you the *right* telescope.

There's nothing mysterious about *this* Sphinx!

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep objects.

Vixen Star Book hand control showing star chart display

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances quickly.

The Star Book control's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book can be used as a stand-alone star atlas anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in ultra-premium Vixen scope packages ranging from a 3.1" f/5 refractor on a supremely portable go-to tabletop mount to big 8" go-to reflectors and catadioptrics on full length field tripods.

FL80SWT-SXW 3.1" f/8 fluorite apo Vixen refractor on Sphinx go-to mount
$3910

You'll find full Vixen Sphinx details and prices on our **www.astronomics.com** website.

The Stellarvue refractor is a "hot new product."

This is the newest version of the **Stellarvue AT1010** refractor that was named a "Hot New Product" by *Sky & Telescope*. The 78mm f/6.15 multicoated achromatic optics are triple-tested and hand-assembled. It has a self-storing dew shield, dust covers, tube ring with 1/4"-20 thread mounting holes and finder mounting block, 2" rack and pinion focuser, 1.25" eyepiece adapter, and a quick release red dot finder.

The AT1010N is a super deal. It's just one of the 78mm to 102mm Stellarvue refractors we stock.

AT1010N **$499** shown w/optional 2" diagonal and eyepiece

Eyepiece cases start at only $2.49!

These bolt-type containers keep your eyepieces free from dew and dust. Foam inserts cradle the eyepieces to protect against accidents. Our website at **www.astronomics.com** lists which specific eyepieces fit into which containers.

42mm x 60mm holds most Celestron Omni and E-Lux, Meade Series 3000, and TeleVue Plössls.	$2.49
52mm x 80mm holds TeleVue Radians, Nagler Type 6, most Barlows, large Celestron Ultimas, etc.	$3.49
65mm x 80mm holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	$3.99
65mm x 120mm holds longer Barlows, 55mm Plössl, 22mm and 27mm Panoptic, etc.	$4.99

Our *38* light pollution filters make bright skies dark.

If city lights wash out your view of the skies, get rid of the light pollution with one of the 38 different light pollution filters we stock.

We have two **Celestron** broadband filters. One for 1.25" eyepieces and one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, Oxygen III, and narrowband filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus their unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

$100 factory rebates on Canon!

Sky & Telescope said that hand-holding image-stabilized Canon binoculars was "a quantum leap in binocular observing." You simply see more detail with Canon's electro-mechanically stabilized images. There are no tremors from tired or cold hands to blur the image. Best of all, there's a $100 rebate through 1/31/04 on the two 50mm models best for astronomy. Details are on our website at **www.astronomics.com**.

Sirius minus violet . . . for serious astronomy.

Sirius minus violet filters reduce the purple haze of chromatic aberration that's visible around bright objects in all inexpensive achromatic refractors. With spurious color reduced, achromats can approach costly apochromatic scopes in performance. Is $74.95 such a big price to pay for a 1.25" eyepiece filter that can turn your achromat into a near-apo? We don't think so. If you're serious about getting the most out of your refractor, see the Sirius filters on our website.

Meade go-to . . . *at prices you can live with.*

Meade 5" AR-5 refractor
$695

Why pay for an ordinary refractor or reflector when you can get a fully computerized Meade LXD55 for the same price? The go-to LXD55 series is the biggest advance in an affordable mount since the German mount was invented in the early 1800s!

You won't spend your time hunting for faint deep space objects with a 5" or 6" LXD55 refractor or a fast Schmidt-Newtonian 6", 8", or 10" reflector (with either standard or optional UHTC optics). A few touches on the built-in Autostar computer sends your scope speeding to any of more than 30,000 stars and objects, centers the object, and tracks it as you observe. You spend more of your time looking *at* deep space objects and planets and less time looking *for* them with an LXD55.

Each is complete with adjustable height tripod, dual motor drives, accessory tray, finderscope, eyepiece, and Autostar computer. Order now and get your German equatorial mount observing out of the dark ages.

$839
Meade 8" SN-8 f/4 reflector ($964 w/UHTC)

Right angle finders available from stock from $89.

We stock **Antares** 8 x 50mm and 11 x 80mm right angle finders at prices from $89 to $217.50. Choose from gloss white, Celestron black, or Meade blue in your choice of a mirror-image or erect right-reading version that shows you the sky the way it appears on star charts. Optional mounting rings are also available.

Antares 11 x 80mm
$210

Get a go-to *now.* Celestron ships from stock.

Celestron Advanced Series scopes put multicoated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to that's right for you and your budget. You can even get industry-leading XLT coatings as an option on the bigger SCTs. The scopes include:

an 8" Newtonian reflector	**$949.00**
a 6" achromatic refractor	**999.00**
a 5" Schmidt-Cassegrain	**1099.00**
a 10" Newtonian reflector	**1149.00**
an 8" Schmidt-Cassegrain	**1299.00**
an 8" SCT with XLT coatings	**1424.00**
a 9¼" Schmidt-Cassegrain	**1699.00**
and a 9¼" SCT with XLT coatings	**1874.00**

Each has a heavy duty adjustable height tripod with rigid 2" diameter steel legs instead of the lighter aluminum used in other scopes. Their go-to computers have a library of 40,000+ stars and objects they can find for you. High slewing speed dual-axis DC servo motor drives are standard. The list of features goes on and on – all at prices starting as low as $949. And the new optional XLT coatings on the SCTs are 11% brighter than competitive multicoatings.

Celestron C 8 S-GT 8" go-to
$1299
($1424 with optional XLT coatings)

Celestron long eye relief ED eyepieces for $64.95!

Celestron X-Cel ED 55° field *six-element* eyepieces set new standards in affordable performance. Available in 2.3, 5, 8, 10, 12.5, 18, 21, and 25mm, these parfocal eyepieces are fully *5-layer multi-coated,* with blackened lens edges for higher contrast. They all have a long 20mm eye relief for eyeglass use and come in protective plastic cases. ***At only $64.95 each, they are incredible visual values.***

Tectron tools make collimating easy!

Tectron collimating tools are a must for getting the most out of your Schmidt-Newtonian or Dobsonian. The $43 Tectron Cheshire tool, left, will have your reflector performing like a million bucks! Buy it alone or in a $115 set that includes an autocollimator and sight tube. No self-respecting reflector should be without one.

A Celestron rechargeable battery for only $59.95!

It's our best-selling accessory ever. We order 200 at a time and still have trouble keeping them in stock! The **Power Tank** 7 amp-hour 12V DC rechargeable battery runs your scope all night long. It has two cigarette lighter outputs; separate 3, 6, and 9V DC accessory outputs; emergency spotlight; recharger; shoulder strap; and more. It's only $59.95. Why pay more for a battery that does less?

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at www.astrofieds.com

New and exceptional. Denkmeier Binoviewers.

When you use both eyes to view, you see up to 40% more detail than you do through a single eyepiece. Lunar, planetary, and deep space views become vivid and almost three-dimensional.

Denkmeier Binoviewers add that new dimension to your observing. Starting at $599, they are widely recognized as a superb value for any observer who wants to get the most out of his or her telescope. Full details and prices on the web at **www.astronomics.com**.

Meade ETX Maks now come with tripod and Autostar!

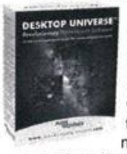
ETX-125EC
$995, complete

The best-selling Meade ETX Maksutov-Cassegrains just got even better. They now come in a package that includes a heavy duty tripod and Autostar computer for less than the former cost of the same components bought separately. Prices start at only $595 for a full-featured go-to telescope with everything you need to start observing as soon as you get it. Each has an adjustable height tripod, Autostar computer with 30,223 star and object memory, 26mm Super Plössl eyepiece, and more. Optional UHTC (Ultra High Transmission Coatings) optics are available for images up to 20% brighter than standard optics so you can see 20% more of the Universe.

Authorized Meade Dealer

Best-selling Meade ETX Maksutovs, now better than ever – and they're in stock!

This $199.95 box holds the entire Universe!



Desktop Universe is a full-color photographic star atlas combined with a powerful desktop planetarium program. It shows you stars to magnitude 14, the visual limiting magnitude of an 8" telescope. It shows star clusters, nebulas, and galaxies as your eye sees them through your scope, not as abstract symbols the way other planetarium programs show them. *Sky & Telescope* named it a Hot New Product and called it "visually stunning . . . It just might be the biggest advance in portraying the night sky since the paintings on the ceilings of Egyptian tombs." Of course it also controls your go-to telescope, prints sky charts for use at your scope, and does all the other useful things a great planetarium program should.

Everyone can afford CCD when cameras start at only $249!

SAC CCD cameras finally make serious CCD imaging possible at sensible prices. Even the owners of small scopes (such as the Meade ETX-90) can get into CCD imaging with a very affordable SAC camera.

Whether it's black and white imaging, single-pass full color, tri-color, or auto-guiding – there's an inexpensive SAC CCD camera to do it. You'll find full details and pricing on our website at **www.astronomics.com**.

SAC7B cooled 24-bit color
$499

24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com
Our multiple award-winning Internet address: www.astronomics.com

STORE HOURS: 9-5 Monday thru Friday. Our telephone lines are open 9 to 6 CST, Monday thru Friday, and most Saturdays from 12 to 5.
Mastercard, Visa, Discover, American Express. U. S. sales *only.*
No credit card surcharge. $6.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged.

ASTRONOMY TOUR ALASKA

Astronomy's annual Northern Lights tour to central Alaska featured some of the best aurora viewing any of us had ever seen. /// BY RICHARD TALCOTT

From heaven on Earth...

MOUNT McKINLEY, (right of center), is North America's highest peak at a height of 20,320 feet (6,193m). *ASTRONOMY:* RICHARD TALCOTT

The last things most observers want to encounter on an astronomy tour are bright lights. But we were a breed apart. Lights were what we had journeyed to the far north to see — specifically, the ghostly, glowing, ever-changing northern lights. ☾ Last year, from March 1 to 9, about thirty adventurers braved the late-winter cold of central Alaska for *Astronomy*'s fourth annual aurora-watching expedition, cosponsored by Specialty Tours. And what a trip it was. Every clear night, the lights danced across the frozen stage. Even clear skies weren't an absolute necessity. On one night, patchy clouds enhanced the spectacle, while on another, we could see the greenish glow through a thin overcast.

Two nights stood out. Both featured spectacular horizon-to-horizon shows that started soon after the sky grew dark and continued into the wee hours. Shimmering curtains and pulsing displays were the norm, but intense activity exploded frequently and brilliantly. More often than not, you simply couldn't take in the whole scene — but you didn't hear anyone complain. Green proved to be the dominant color, but we also saw some brighter yellows and occasionally a touch of purple.

We were lucky to be there during a period of increased activity on the Sun, which emits a steady stream of charged particles in our direction. After traversing the 93 million miles to Earth, our planet's magnetic field funnels these particles into the polar regions, creating an auroral band that conveniently passes above east-central Alaska. Aurora-watchers know this is one of the prime observing sites on Earth, and it lived up to its reputation.

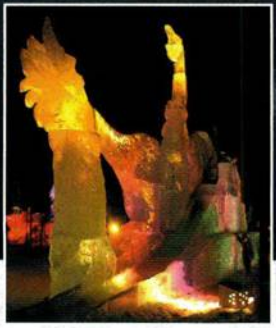
World-renowned aurora expert Neil Brown of the University of Alaska–Fairbanks explained the complex relationships between the Sun, Earth, and atmosphere on our first full day in the 49th state. His detailed descriptions gave the group a

GREEN MEANS GO: (left) Shimmering aurorae perform nightly during *Astronomy*'s annual tours to central Alaska. MARVIN NAUMAN

DANCING EMERALD LIGHTS, (inset and right) caused by charged particles from the Sun spiraling down magnetic field lines in Earth's atmosphere, delight observers with constantly changing patterns. *ASTRONOMY*: RICHARD TALCOTT

RELAX at the hot springs of Chena (above), the first stop on the Alaskan itinerary.

MUSH! Senior editor Richard Talcott (seated) forsakes horsepower as he hurtles along a snowy trail in Chena. MARVIN NAUMAN



A FANCIFUL DINOSAUR doubles as a children's slide at the World Ice Art Championship in Fairbanks, the tour's second destination. MARVIN NAUMAN

"CAUTION: MOOSE HABITAT" reads a small sign next to a large moose in Fairbanks, where moose often wander into the city. *ASTRONOMY*: R. TALCOTT

PSYCHEDELIC LIGHT SHOWS rewarded 2003 tour group members who ventured out into subzero temperatures. A tour bus, though, provided warmer transportation than a dogsled. MARVIN NAUMAN

solid grounding in the mechanics of aurorae, deepening our appreciation of what we were seeing. Other talks during the week covered recent observations from the Hubble Space Telescope and highlights of past, current, and future missions to Jupiter and Saturn.

The best times to view aurorae are around the equinoxes. Near the beginning of both spring and fall, each day receives about 12 hours of darkness and 12 hours of light, enough to enjoy the northern lights as well as the scenery and other outdoor activities. Although the aurorae may be on display longer in the dead of winter, the bone-chilling temperatures make observing a bit more uncomfortable. During our trip in March, we actually saw the thermometer climb above freezing a couple of times, although the coldest night was down around –25° Fahrenheit.

Our group spent the first half of the week at Chena Hot Springs, literally at the end of the road about 60 miles from Fairbanks. During the day, people enjoyed all the activities the resort offered: hiking, snowmobiling, dogsledding, and relaxing in the soothing springs. The dogsled rides proved particularly thrilling, as the dogs followed their mushers' commands, pulling us along well-groomed trails through a pristine forest. The dogs' desire — make that *need* — to run paralleled our thirst to see the aurora. And at Chena, we only had to walk out the front door to see the lights.

Although the dogs at Chena were impressive, they weren't fit to carry the double lead necklines of those we saw in Fairbanks at the annual Iditarod Trail Sled Dog Race. An unusually mild, snow-free winter in southern Alaska led race organizers to move the start from Anchorage to Fairbanks, and many of our group took advantage of the proximity.

The Iditarod commemorates the emergency delivery of diphtheria serum to Nome in 1925. In less than six days and in temperatures rarely above –40° F, a relay of twenty dog teams covered the nearly 700 miles from Nenana to Nome. The sixty-four teams of dogs in the 2003 race ran as though more lives were at stake than the hundreds saved by the epic dash in 1925.

After Chena, we spent the second half of the week in Fairbanks. There we visited the University of Alaska Museum, attended a star party hosted by a local astronomy club, and even saw a moose and her calf wandering through the city. The tour was timed not only to view aurorae during New Moon but also to coincide with the World Ice Art Championship, which takes place in Fairbanks each March. Although the ice sculptures looked beautiful by day, colored lights transformed them into otherworldly creations at night.

From Fairbanks, dark skies are but a short bus ride away, and the auroral activity kept its steady pace. We hope the same holds true in 2004, when we return for another round of aurora viewing and outdoor adventure. Clear your calendars for March 12 to 20, 2004, and sign up today!

Richard Talcott *is a senior editor of* Astronomy.

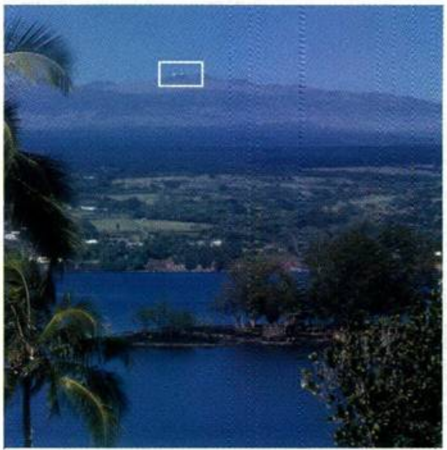
World-renowned observing rewarded *Astronomy* tourists who ascended the dizzying heights of Mauna Kea. /// BY DAVID J. EICHER

...into thin air

Forty ecstatic *Astronomy* subscribers realized their dreams this past April when they accompanied the magazine's expedition to the summit of Mauna Kea, Hawaii. Standing atop this dormant volcano on the Big Island is an array of the world's largest and most sophisticated telescopes, perched to look deep into the universe from the best observing location on Earth. *Astronomy* sponsored a tour with our travel partner, Mayhugh Travel, that lasted from April 26 through May 4, 2003. I had the good fortune to accompany the group on this first iteration of what promises to be an exciting annual event.

The intrepid travelers were lucky — ours was the first group to get a coordinated, behind-the-scenes tour of three major institutions on the mountain's summit. We saw the twin 10-meter Keck telescopes, the largest in the world, along with the 8.1-meter Gemini North telescope and Japan's 8.2-meter Subaru telescope.

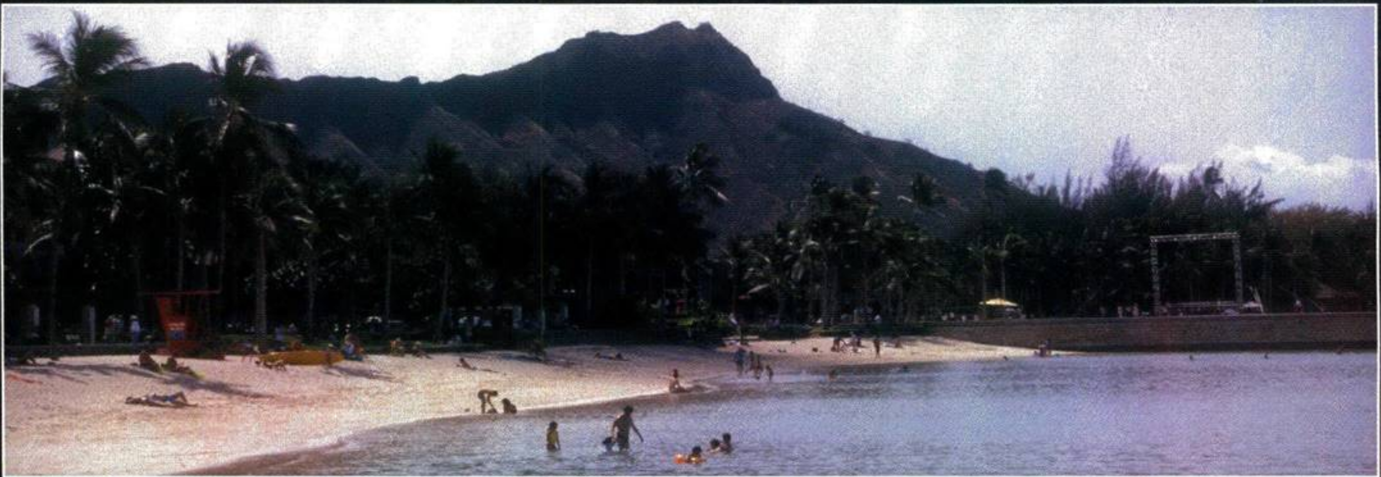
The trip up the low shield volcano is deceptive; the domes are visible from sea level at Hilo, and they look just a short stint away. But it takes one very long hour of driving to reach an altitude of nearly 14,000 feet (4,270m). On the way, we passed thick jungles with waterfalls, groves of macadamia nut trees, and steaming volcanic vents. Finally, we entered a landscape



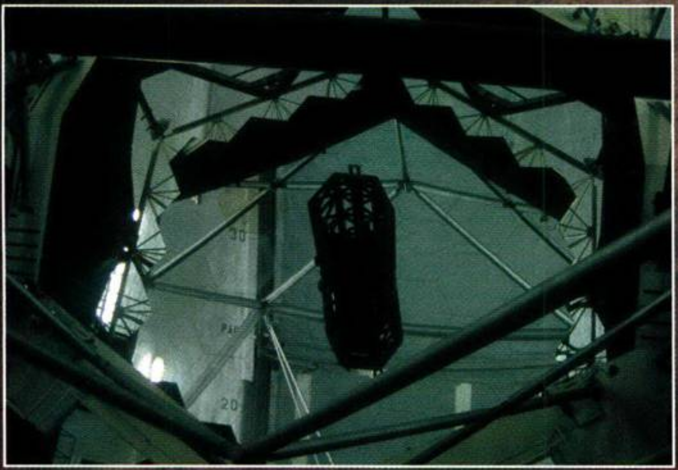
VIEWED FROM HILO through the windows of our hotel, the summit of Mauna Kea beckons with tiny white glints from telescope domes. The shield volcano seems close, but a long journey is required to drive up to its 14,000-foot summit. *ASTRONOMY*: DAVID J. EICHER

***ASTRONOMY'S* INTREPID TRAVELERS** huddle on the windy summit of Mauna Kea, a dormant volcano where many of the world's best telescopes perch. The Subaru and twin Keck domes line the background. JAMES M. KELLY

THE WORLD'S GREATEST TELESCOPES stand atop Mauna Kea. Shown here from left to right are the Canada-France-Hawaii Telescope (silver dome), the Gemini North Telescope, the University of Hawaii 2.2-meter telescope, and the United Kingdom Infrared Telescope. *ASTRONOMY:* DAVID J. EICHER



DIAMOND HEAD looms over the white sands of Waikiki as an ominous reminder of the island's volcanic past. When not enjoying the spectacular cosmic sights through the world's best telescopes, *Astronomy* travelers soaked in the Sun's rays on some of the world's most pristine beaches. *ASTRONOMY:* DAVID J. EICHER



LARGEST IN THE WORLD, the 10-meter Keck I telescope operates in tandem with its twin, Keck II, to act as a giant interferometer. Keck I stands eight stories tall and weighs 300 tons, sporting a massive, hexagonal mirror. *ASTRONOMY:* DAVID J. EICHER

JAPAN'S SUBARU TELESCOPE, its mirror spanning 8.2 meters, dwarfs the *Astronomy* magazine expedition visitors who stand beneath it. Gary Fujihara, control/operating system assistant and founder of Hilo's annual Astronomy Day, describes the telescope to our group. JAMES M. KELLY

that looked more martian than earthlike as we made our way in four-wheel-drive buses to the visitor center at 9,300 feet.

There, we spent an hour and a half adjusting to the thin air. On Mauna Kea's summit, you're 40 percent of the way into space — breathing 40 percent less oxygen. Your body needs to work harder, so you can't stay at that altitude for too long — we managed about four hours. Walking around on the summit made all of us feel like we'd had two quick martinis each.

Following a dynamic tour of the big scopes, we observed the skies from the visitor center with an array of telescopes, some as large as 16 inches, brought up by the Hilo Astronomy Club. To say this was a group of amateur astronomers let loose in a candy store would be an understatement: This was observing in the best skies anyone had ever seen, where familiar objects were transformed into new wonders.

We observed for a second night, drinking in the spectacular views. Then, a number of us made a night walk to the active lava flowing from Kilauea volcano. A journey of about forty-five minutes over month-old pahoehoe lava led to the nearest of many lava fields seeping down to the sea from the crest of a ridge. Crouching a foot away from 2,000° F molten lava is an

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Dave Eicher *is editor of* Astronomy.

EXTREME
BEYON
THIS POINT!
Collapse of lava bench occurs without warning, causing violent steam explosions and ocean surge.
1
2

EXTREME D— ! Anyone hunting active lava fields doesn't need to read the rest of this sign to know what it means. ASTRONOMY: DAVID J. EICHER

OIL LEAKS SLOWLY from the skeleton of the USS *Arizona* at Pearl Harbor as the battleship USS *Missouri* lurks in the distance. ASTRONOMY: DAVID J. EICHER

FLOWING, MOLTEN LAVA bubbles, cracks, hisses, and pops before it finds a low spot and begins to solidify into rock. ASTRONOMY: DAVID J. EICHER

amazing experience. The lava oozes and bubbles, breaking out of rock and slowly finding settlement like taffy rolling over itself. Then the lava hardens, darkens, and cools, the rock-like shell that encases it popping, cracking, hissing, and splitting.

Our group — which consisted of several British and Dutch travelers, the president of the Swiss Astronomical Society, as well as Americans and Canadians — enjoyed a behind-the-scenes tour of the Science Tech Park in Hilo, about 20 miles away on the island's eastern coast. This serves as the operations center for the big scopes on the mountain.

We also spent several days on Oahu, swimming at Waikiki, exploring Honolulu, and seeing the USS *Arizona* Memorial and the USS *Missouri*, on which Japan surrendered, ending World War II. We relaxed in the shade of Diamond Head and basked in the glory of Waimea Bay.

It was a glorious trip that made everyone involved giddy. Managing editor Patricia Lantier will accompany a group to the summit and to Hawaii's greatest locales from April 17 to 24, 2004. If you're interested in visiting the world's greatest observatories, sign up early. The limited number of seats will go fast. ■

To learn more about *Astronomy* trips, visit www.astronomy.com/toc

MOON OBSERVER'S NOTEBOOK

The lunar Apennine Mountains mark the southeastern edge of a huge impact basin now flooded with lava. /// BY ROBERT BURNHAM

Lunar Apennines

Around First Quarter, the Sun rises over one of the Moon's most striking sights: the Montes Apenninus or Apennine Mountains. This rugged chain marches in a curving line for 370 miles along the southeastern edge of Mare Imbrium and ends at the magnificent crater Eratosthenes. ☾ The Apennines are a relic of a benchmark event in lunar history — the impact of an asteroid 3.85 billion years ago that blasted a basin 720 miles across and 35 miles deep. The impact dug into the crust and flung debris far and wide, creating secondary craters over much of the Moon. The Imbrium basin is the largest surviving impact scar on the Moon's near side; it became Mare Imbrium as lava flows coalesced to fill the basin.

On the boundary of the mare, the front side of the Apennines slopes gently at a 20° angle. The back side of the range falls away even more gradually, its foothills melding into the lava flows of **Mare Vaporum**. Another lava pond hemming the Imbrium debris is **Sinus Aestuum**; on its eastern edge, dark volcanic material erupted explosively along a rille, **Rima Bode**, mantling a small area. (The dark region becomes more apparent as the Sun climbs higher in the sky.)

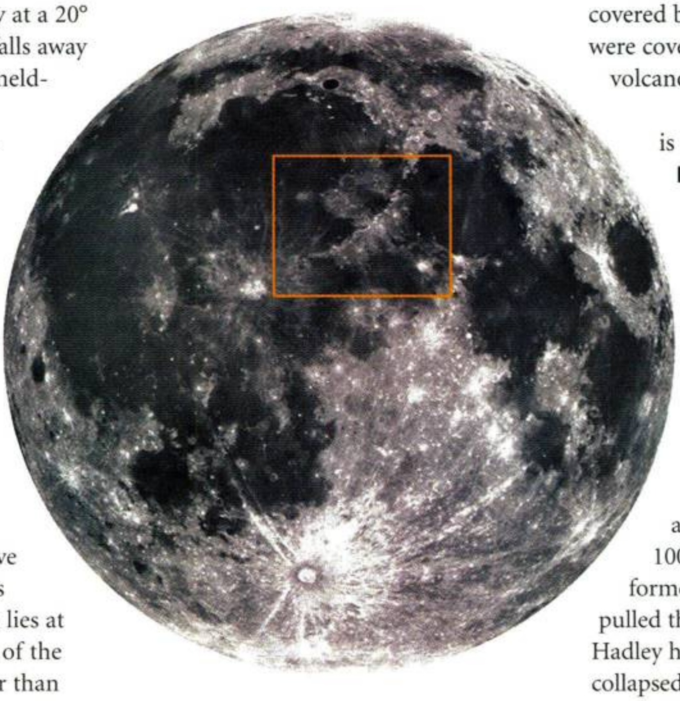
The tallest peak in the Apennines is **Mons Huygens**, which is located near the center of the mountain chain. It stands 14,500 feet above the mare. Observe the Apennines with magnifications between 100x and 150x. If the Sun lies at a low angle, you'll notice the front of the Apennines looks distinctly blockier than the long backslope. The backslope is composed of fractured and shaken bedrock covered with a thinner coating of ejecta.

About 15 miles into the mare, a broken line of low ridges parallels the front of the Apennines. These ridges are the tops of gigantic blocks that slumped away from the Apennines shortly after the basin impact. Mare lavas covered most of the blocks, so only the tops are visible now.

Extending from the Apennines toward the flooded crater Archimedes is an area of light-tinted plains embedded with rough terrain — the **Apennine Bench**. A smaller patch lies to the north, near the crater Autolycus. The Bench is the only place where the Imbrium basin floor was not covered by lava flows. The light plains were covered by a non-mare lava when a volcano erupted after the basin impact.

Dividing the two Bench deposits is a patch of mare known as **Palus Putredinis**. The Apollo 15 lander touched down where the mare meets the mountain scarp. Excellent seeing, a low Sun angle, and magnifications above 200x show a mile-wide meandering rille, **Rima Hadley**, which the astronauts visited.

Examine the Apennine Bench's southeastern end using 200x. A rille named **Rima Bradley**, a two-mile-wide groove, stretches 100 miles. The rille is a tension crack formed as cooling lava settled and pulled the rock in this area apart. Rima Hadley had a different formation — it is a collapsed lava tube. The observability of lunar rilles depends on their depth; shallow rilles like Rima Hadley are usually low contrast features, which are difficult to observe.



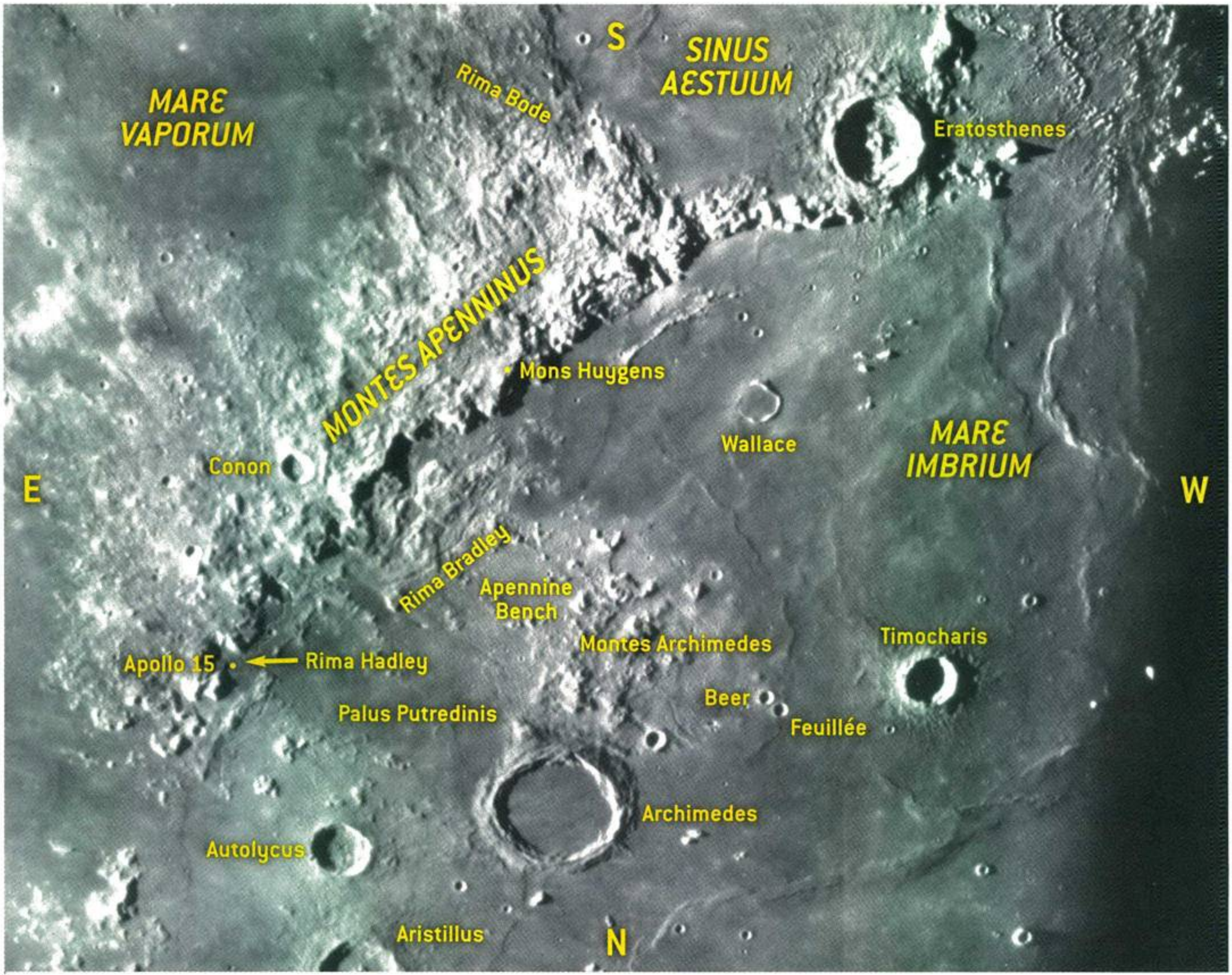
THE LUNAR APENNINES form part of the boundary of Mare Imbrium. This image appears "naked eye," with north at top. LICK OBSERVATORY

/// BEST DATES TO OBSERVE

Lunar sunrise and sunset are the best times to view the Moon because shadow detail is greatest then. The best dates to observe the Moon's Apennine mountains for the next three months are listed below.

Lunar sunrise
Jan. 29–31, Feb. 28–29, Mar. 29–31

Lunar sunset
Jan. 13–15, Feb. 11–13, Mar. 11–13



MARE IMBRIUM'S SOUTHEASTERN EDGE, shown here with south at top (the view through most telescopes), is a treasure trove of observing delights. This is plate C-13 from the *Consolidated Lunar Atlas*. LUNAR AND PLANETARY LABORATORY

At the northwest end of the Bench lie the **Montes Archimedes**, remnants of a ring of mountains within the Imbrium basin. The biggest crater here is **Archimedes**, which measures 52 miles across. The formation of Archimedes occupies a special slice of time — after the Imbrium impact but before the basin filled with lava. A smaller example is **Wallace** (16 miles wide). Because of the size difference between these two craters, Archimedes (with higher crater walls) is far better preserved than Wallace, which was nearly obliterated by the Imbrium impact.

Secondary craters and ejecta produced by the formation of Archimedes lie atop the Bench deposits forming a sequence: basin impact, Bench formation, Archimedes impact, and finally, mare lava flows. Mare Imbrium took a long time to fill with lava. Apollo 15 astronauts collected surface samples from Palus Putredinis and from the Apennine scarp; the ages of these samples differ by 550 million years.

Three impact craters near Archimedes formed after mare lava filled the basin: **Timocharis** (21 miles wide), **Autolycus** (24 miles), and **Aristillus** (34 miles). Timocharis appears to be the youngest. Use 200x to reveal its braided ejecta apron, slumped terraces within the walls, and a floor with smooth areas of pooled impact melt. It's a small gem.

Autolycus, dated at 2.1 billion years old, has a floor with few level areas and multiple hills. Its interior surely includes debris from nearby and younger Aristillus.

Low sunlight reveals many wrinkle ridges snaking across the mare surface where thin lava flows buckled. Prominent ones lie northwest of **Eratosthenes**, a crater 36 miles across. This crater takes many nights to explore fully as varying Sun angles reveal its details. At local sunrise, use 200x to trace its hilly ejecta blanket and find the tiny pits of its secondary craters. When the Sun is higher above Eratosthenes, look inside the crater for a network of terraces that formed when the interior wall collapsed moments after impact. This network is thought to be 3.2 billion years old. Finally, use magnifications above 200x to pick out the crater's tangled central peak and flat floor of rock melted by the impact. Like its big brother Copernicus a short distance to the southwest, Eratosthenes offers earthbound lunar astronauts a fine sight to explore. ■

Robert Burnham *is a senior editor of* Astronomy *and the author of the recently released* Exploring the Starry Sky *(Cambridge University Press). He is working on a new book,* The Moon: a Telescopic Guide (CUP).

PRODUCT REVIEW

This rich-field Newtonian telescope is a great value for kids of all ages.

/// BY PHIL HARRINGTON

Orion's StarBlast

"You kids today have it too good." Did you ever hear that when you were growing up? I sure did. I try not to fall into the same generational trap, but when it comes to telescopes, kids do have it good today. Back in 1969, my first telescope was a 4-inch reflector that had appalling optics and a wobbly mount. It sold for $29.95.

According to the United States Department of Labor, inflation has made that $29.95 worth $150 today. Would I spend that much on a similar telescope for a child who was just getting interested in astronomy? Absolutely not, especially when I could purchase the StarBlast from Orion Telescopes & Binoculars for the same $150. The StarBlast is a great telescope for both young observers as well as those who are young at heart.

EXPLORER II 17 mm
EXPLORER II 6 mm

EXPLORER II 1¼" EYEPIECES included with the StarBlast have focal lengths of 17mm (26x) and 6mm (75x). *ASTRONOMY*: WILLIAM ZUBACK

"Daddy, what's a StarBlast?"

Designed by Orion and manufactured in China by Synta, the StarBlast is a compact 4.5-inch f/4 Newtonian reflector, or what's often called a "rich-field telescope" (RFT). The scope comes ready to use, complete with a tabletop alt-azimuth mount, 6mm and 17mm Explorer II 1¼" eyepieces, a single power EZ-Finder II, dust caps, a collimation tool, a copy of the student edition of *TheSky* planetarium program on CD-ROM, and an instruction manual. All you need is a clear sky.

Orion markets the StarBlast as a kid's scope, but in truth, anyone who enjoys scanning the Milky Way or viewing large targets like the Pleiades and the Andromeda Galaxy will enjoy this telescope. Traditionally, offering low-power, wide-field views is what RFTs do best. They are less suitable for high-powered observing because that requires short focal length eyepieces or Barlow lenses, which increase the magnification but decrease the field of view. The observer, therefore, has to move the telescope more often as the object drifts out of the field.

StarBlast details

Outwardly, the tube of the bluish-green StarBlast looks like it's riding on half of a Dobsonian mount. Because the StarBlast's tube assembly is lightweight (the entire assembly weighs only 13.5 pounds without an eyepiece), the designers rightfully felt that a full Dobsonian mount would offer no additional benefit. So the StarBlast comes attached to a stubby "one-armed" mount that's light enough to be carried by a child, yet sturdy enough to support the optical tube assembly.

Like Orion's larger Dobsonian-mounted telescopes, the StarBlast's mount is made from laminated chipboard. Teflon altitude and azimuth bearings produce smooth motions in both directions with no backlash. Tension on the altitude bearing can be adjusted by loosening or tightening a large knob that presses against a ball-bearing collar sandwiched between two washers. This simple feature proved very useful during testing because I used a wide variety of eyepieces that weighed anywhere from a few ounces to more than a pound.

I was also thankful the StarBlast's tube could be rotated easily in its hinged, felt-lined, metal clamp just by loosening a large thumbscrew. Doing this let me balance the telescope perfectly no matter which eyepiece I used. It also allowed me to rotate the tube so I could look through the eyepiece comfortably wherever I aimed the telescope. The optical tube assembly also can be removed from the mount for easy storage or cleaning, should the need arise.

The StarBlast in its mounting stands only 25 inches tall, which makes it a great grab-and-go telescope for impromptu observing. Be sure to bring along something to elevate the scope off the ground because it's much too short to use alone. I used a short, plastic patio table, but some might prefer a picnic table, a barstool, or some other sturdy support. It's best if the support touches the ground in three places like a tripod, as my four-legged table proved a little wobbly. I know some owners who use an upside-down wastepaper basket or an empty 5-gallon paint can, but these may rock on uneven ground.

ORION EZ Finder II
WARNING!
ORION

THE STARBLAST quickly assembles into the easy-to-carry telescope pictured here. *ASTRONOMY*: WILLIAM ZUBACK

StarBlast setup

Our StarBlast, purchased and shipped directly from Orion, arrived safely in a double-lined box. Unlike some beginner telescopes that come with incomplete or poorly written instructions, the StarBlast owner's manual gives thorough information about setting up, maintaining, and using the telescope. The instrument itself emerges from its box almost completely set up. Just attach the base of the EZ Finder II to matching mounting screws that protrude out of the telescope tube, and the StarBlast is ready to go.

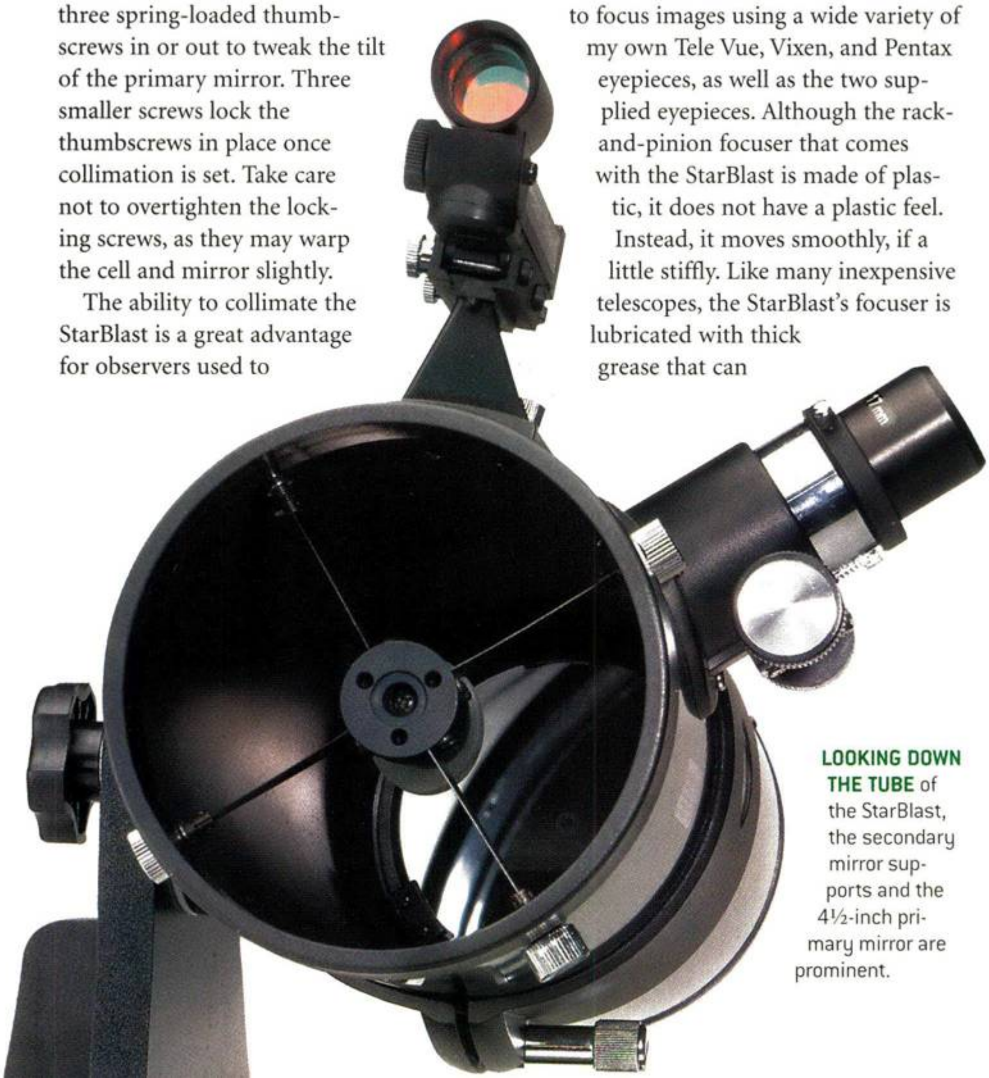
Our test telescope was delivered in perfect optical collimation (the alignment of the optical components of a telescope) despite its cross-country trek. Proper collimation is important for all Newtonians, but especially for those with focal ratios of 6 or less. Unlike Edmund's Astroscan and the similarly designed Bushnell model 78–2010, which both have collimation set at the factory and cannot be adjusted by owners, the StarBlast includes a primary-mirror cell that's easy to adjust.

To collimate the telescope, adjust three spring-loaded thumbscrews in or out to tweak the tilt of the primary mirror. Three smaller screws lock the thumbscrews in place once collimation is set. Take care not to overtighten the locking screws, as they may warp the cell and mirror slightly.

The ability to collimate the StarBlast is a great advantage for observers used to inexpensive telescopes that use three thick vanes to hold the mirror in place. The StarBlast's adjustable secondary mirror support uses four razor-thin vanes to minimize intrusive diffraction spikes that form around bright objects.

Focuser travel was more than adequate to focus images using a wide variety of my own Tele Vue, Vixen, and Pentax eyepieces, as well as the two supplied eyepieces. Although the rack-and-pinion focuser that comes with the StarBlast is made of plastic, it does not have a plastic feel. Instead, it moves smoothly, if a little stiffly. Like many inexpensive telescopes, the StarBlast's focuser is lubricated with thick grease that can be a little gummy. Once I removed the focuser's pressure plate, cleaned the gearing with a degreaser, and relubricated it with a dry silicone spray, the focuser worked much more smoothly. (This procedure should be performed by an adult.)

THE ALT-AZIMUTH MOUNT of the StarBlast moves easily and holds the telescope's tube securely. *ASTRONOMY:* WILLIAM ZUBACK



LOOKING DOWN THE TUBE of the StarBlast, the secondary mirror supports and the 4½-inch primary mirror are prominent.

The StarBlast at work

Because I've always enjoyed wide-field views of large deep-sky objects, I have a soft spot in my heart for small, short-focus Newtonian reflectors. As luck would have it, the StarBlast arrived during a clear spell in July, just as the summer Milky Way was ascending in the evening sky. I was impressed with what I saw.

Showpiece objects like the Lagoon Nebula (M8) in Sagittarius and open clusters M6 and M7 in Scorpius were sharp and clear through the four-element 17mm Explorer II eyepiece (26x). The 6mm Explorer II (75x) resolved a few individual stars around the edges of the Hercules Globular Cluster (M13), although the eyepiece's inherently short eye relief made viewing rather difficult. It would have been preferable if Orion had supplied, say, their 10mm Explorer II eyepiece and a 2x Barlow lens instead. That combination would yield 90x and offer better eye relief.

As I continued across the sky, I paused at the globular cluster M4 in Scorpius. Its "star bar" was clearly visible, and I was able to resolve some stars around the cluster's edge. The Swan Nebula (M17) and its surrounding star field were striking at low power, as was the Dumbbell Nebula (M27) in Vulpecula. The Ring Nebula (M57) was visible through the 17mm eyepiece, but I needed the extra magnification of the 6mm to see its smoke-ring shape.

Several double stars including Albireo (Beta Cygni), Rasalgethi (Alpha Herculis), and Mizar (Zeta Ursae Majoris) were resolved nicely through the StarBlast. And both pairs of Epsilon Lyrae, the famous Double-Double, split cleanly with the 6mm eyepiece.

Turning my attention eastward, I centered on Mars, last summer's showstopper. I didn't expect the StarBlast to show much detail on the Red Planet because the telescope's short focal length is better suited for Milky Way star fields than for detailed

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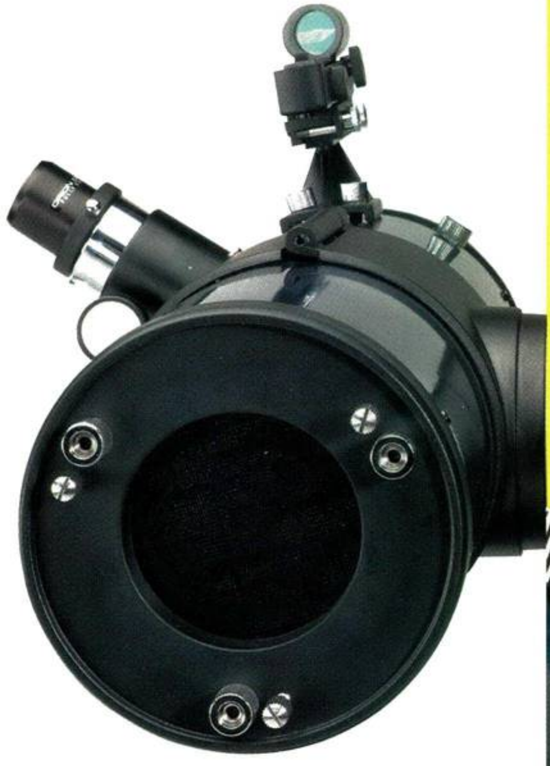
Phil Harrington *is the author of the new observing guidebook,* Star Watch, *published by John Wiley & Sons.*



THE COLLIMATION SCREWS are easy to reach at the back of the tube. ASTRONOMY: WILLIAM ZUBACK

ORION
FULLY C

THE FOCUSER accommodates 1¼" eyepieces and moves smoothly. ASTRONOMY: WILLIAM ZUBACK

views of planets. Still, the StarBlast did a respectable job, easily revealing the south polar cap as well as a subtle indication of Syrtis Major on the martian surface.

Using premium eyepieces

While the two eyepieces included with the StarBlast are quite capable of introducing the night sky to young or beginning astronomers, I couldn't resist the temptation of testing it with a few of my own eyepieces. Of course, we need to keep this in perspective because each of the eyepieces I used cost more than the StarBlast. But that said, I must admit the StarBlast impressed me greatly even when I used premium-grade eyepieces.

Both M8 and the nearby Trifid Nebula (M20) easily squeezed into the same field of my 22mm Tele Vue Panoptic eyepiece, as did NGC 6960 and NGC 6992/5, the two major segments of the Veil Nebula in Cygnus. The entire cosmic continent of the North America Nebula (NGC 7000) in Cygnus also fit nicely in the Panoptic's field and stood out surprisingly well when viewed through a nebula filter. I enjoyed many other memorable sights through the StarBlast, including the Double Cluster in Perseus (NGC 869 and NGC 884) and the Andromeda Galaxy (M31).

Back at Mars, a 10mm orthoscopic eyepiece combined with a 2.5x Powermate Barlow lens (yielding 113x) gave a fine view of the major dark marking on the martian surface, Syrtis Major, as well as the south polar cap, with the cap's darkened rim quite obvious. Next, I revisited the Ring Nebula (M57) and the Double-Double, both in Lyra. To my delight, both were resolved clearly. In fact, all four members of the Double-Double showed nicely defined diffraction rings when viewed through a 7mm Pentax XL eyepiece and 2.5x Powermate, which gave the scope a magnification of 161x.

StarBlast optics

Star-testing the StarBlast proved what I suspected all along — the telescope's optics are very good. Bench testing proved that the primary mirror's surface is smooth, with no zones and only the slightest turned edge, quite an accomplishment for an inexpensive, mass-produced telescope like the StarBlast.

The Orion StarBlast certainly lives up to its name. It's a blast to use! Although it's not as suitable for viewing planets as Orion's longer focal length SkyQuest XT4.5 (which costs more but also includes two superior Plössl eyepieces), I was kept busy for hours going back and forth between old deep-sky friends. Is the StarBlast for kids? Absolutely! Its compact size and light weight make it an ideal telescope for ages 9 or so and above. And when I say "above," I mean the sky's the limit because kids from 9 to 90 really will enjoy this telescope. ■

/// PRODUCT SPECS

Orion StarBlast 4.5-inch f/4 Newtonian reflector

Weight: 13 lbs.

Tube length: 18 inches

Eyepieces: Explorer II 17mm and 6mm

Finder: EZ Finder II

Focuser: 1¼" rack-and-pinion

Also includes: collimation tool, dust caps, *TheSky* (student edition), instruction manual

Contact information

Orion Telescopes & Binoculars
P. O. Box 1815
Santa Cruz, CA 95061–1815
[t] 800.447.1001
[w] www.telescope.com

Use this guide to get the most out of this season's great appearance of Saturn.

/// BY JULIUS L. BENTON, JR.

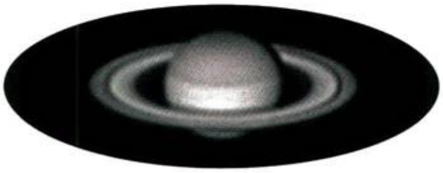
Saturn in prime time

Think back to the time when you purchased your first telescope, learned to set it up correctly, and started to observe. Which object thrilled you the most? Or, alternately, which object you show to others through your telescope now gets the best reactions? Overwhelmingly, amateurs answer these questions with one word: Saturn.

On December 31, 2003, Saturn will reach opposition barely four hours before the new year begins (Universal Time). It will appear as a bright yellowish object at magnitude –0.5 in the constellation Gemini. The crisp, clear winter skies should afford observers optimum views of Saturn, whose southern hemisphere and south face of the rings are presently inclined toward Earth.

An apparition (observing season) of Saturn spans about ten months. Because the annual eastward motion of Saturn relative to the background stars is 12°, the planet can stay in one constellation for several years. The current apparition began in early July, when Saturn emerged from the solar glare in the morning sky. The planet will remain accessible until mid-June 2005, when it will sink too low in the western sky after sunset for useful observations. At opposition (when Saturn lies opposite the Sun as seen from Earth), Saturn's globe will subtend an angle of about 21" in equatorial diameter, while the major axis of the rings will span 47". During good seeing, the more prominent features of the globe and rings should be visible through a 3-inch telescope.

Novice observers using small apertures often think Saturn is barren and changeless, seldom displaying the wealth of activity seen on Jupiter. Saturn, however, requires nearly twice the magnification needed for its jovian neighbor to produce a disk of comparable dimensions. Once this is realized, observers discover the planet displays many features that beckon regular surveillance.



SATURN IN POOR SEEING still shows detail; the A ring, B ring, and Cassini Division are easy to identify. (Celestron 11-inch Schmidt-Cassegrain telescope at f/23, Phillips ToUcam Pro webcam, January 23, 2000) TAN WEI LEONG

Standard telescope recommendations for detailed studies of Saturn are 6-inch refractors or 10-inch reflectors, but experienced observers — using surprisingly small instruments — have achieved some remarkable results in the past. The key is to find the right blend of telescope aperture and magnification so that image brightness and contrast are maximized without sacrificing resolution.

Global features

Moderate-size telescopes show a series of white or pale yellowish zones and darker yellowish-brown or bluish-brown belts running across the globe of Saturn parallel to its equator.

In a normal inverting telescope, south is at the top of the image, and features move across the globe of Saturn from right to left. The International Astronomical Union determined in 1961 that east and west in recorded data should reference true east and west on a planet, so the right-to-left motion just mentioned occurs from west to east. As seen through an inverting telescope, Saturn's globe casts a shadow on the ring system to the left (east) prior to opposition, to the right (west) after opposition, and on neither side exactly at opposition (no shadow).

Through small telescopes, the obvious features on the globe are the Equatorial Zone (EZ), the North and South Equatorial Belts (NEB and SEB), and the South Polar Region (SPR). Observers with large telescopes may see the SEB differentiated into north and south components (SEBn and SEBs), which are separated also by a brighter zone (SEBZ). Some less distinct belts and zones, such as the South Tropical Zone (STrZ), South Temperate Belt (STeB), and South Temperate Zone (STeZ), should be visible with 10-inch and larger apertures during good seeing.

Discrete phenomena in the belts and zones, such as dusky festoons and bright ovals, may be seen occasionally. Analysis of long-term data suggests a pattern of major atmospheric outbursts. For example, extremely brilliant bluish-white spots were reported in the EZ by Asaph Hall in 1876, by Edward Emerson Barnard in 1903, by Will Hay in 1933, by J. H. Botham in 1960, and most recently by Stuart Wilber in 1990, suggesting an approximate 30-year recurrence of prominent white spot outbreaks. Over time, these features diffused longitudinally within the EZ, elevating the brightness of this area for many weeks. Smaller and less conspicuous white ovals may appear unexpectedly at any time.

Sketching and imaging

Observers are encouraged to attempt accurate drawings of Saturn. Drawing pencil sketches trains the eye to perceive delicate contrasts and subtle differences between features. Blanks depicting the proper oblateness of Saturn's globe are distributed by the Association of Lunar and Planetary Observers (ALPO) Saturn Section, and space is available on the forms for additional data such as date and time of the observation, observing site, instrument and magnifications, and filters used. Download the forms off the Internet from www.lpl.arizona.edu/alpo.

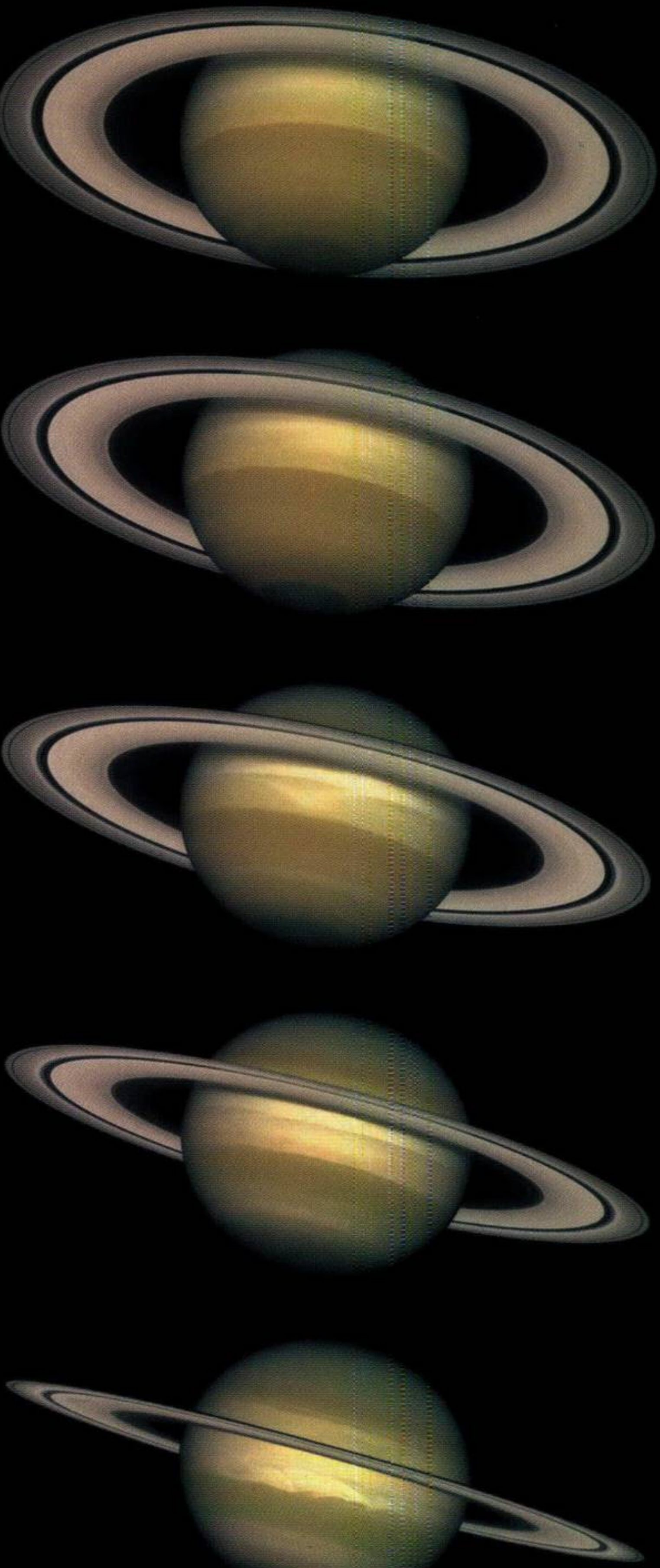
Systematic imaging of Saturn using digital, CCD, video, and regular film cameras is extremely valuable, but imaging should not replace descriptive visual reports. Simultaneous observations, when two or more independent observers draw or image Saturn at the same time and on the same date, are immensely important. Because singular visual impressions of variable phenomena in the planet's atmosphere are subjective, confirming reports from other observers are necessary to improve confidence in the data.

High-velocity winds blow in different directions in adjacent bands on Saturn, creating three systems of rotation in the atmosphere that depend on latitude. System I rotates in 10 hours, 14 minutes, 13 seconds, and includes low latitude features such as the EZ, NEB, and SEB. System II applies to higher latitudes and moves at a rate of 10 hours, 38 minutes, 25 seconds, while System III refers to extreme polar regions and has essentially the same rate as System I.

Observers who detect phenomena on Saturn should record to the nearest minute when the center of the feature is exactly on (transits) the Central Meridian (CM) of the globe. The objective is to "recapture" the same feature if it appears on the CM in a subsequent rotation. If a feature persists long enough for repetitive CM transits, it is possible to calculate the rotational rate of Saturn's atmosphere at that latitude. Decades of data on long-enduring spots on Saturn have confirmed a definite variance in the rotational rates of the SEB and NEB, for example.

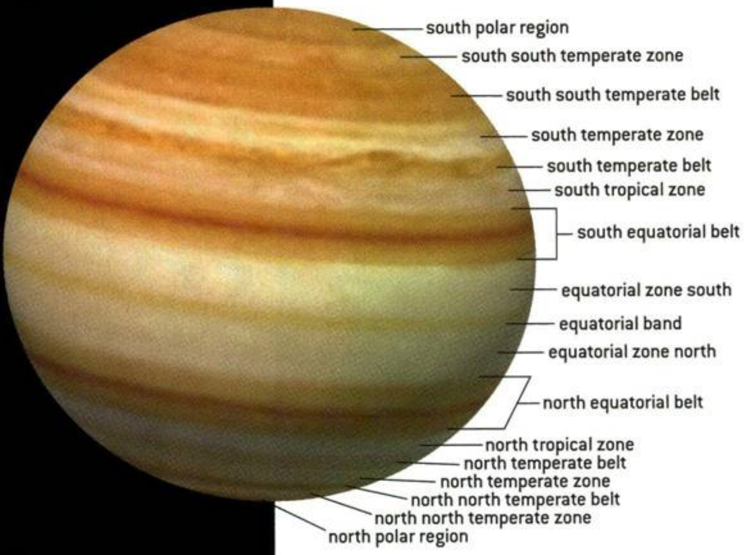
Estimating intensity

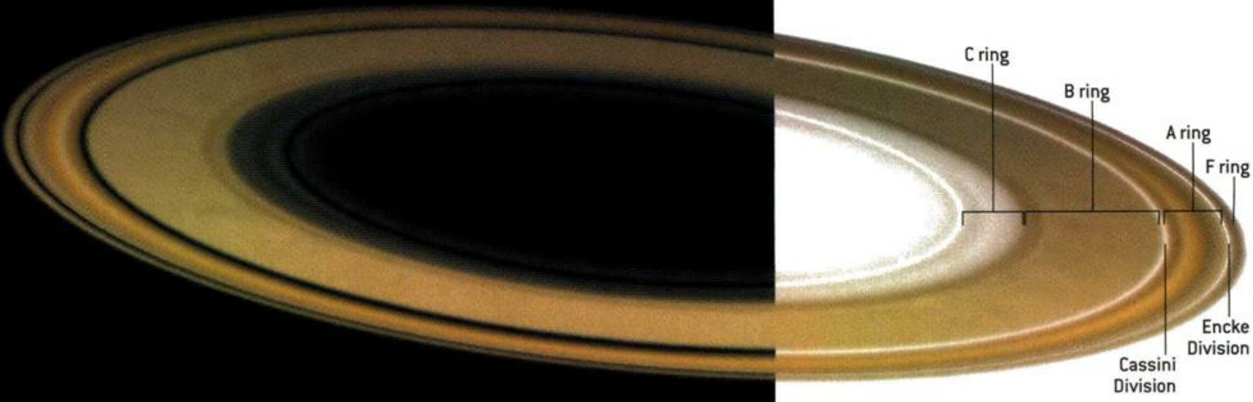
The brightnesses and hues of Saturn's belts, zones, and any temporary features



THE HUBBLE SPACE TELESCOPE imaged Saturn for five years, from 1996 (bottom) to 2000 (top), as the planet's rings became more open to our view. R. G. FRENCH, HUBBLE HERITAGE TEAM

SATURN'S ELUSIVE ENCKE DIVISION was discovered by astronomer James Keeler in 1888. The division is a 200-mile-wide gap at the outer edge of the A ring. It spans only 0.05", making it one of the smallest planetary features resolvable from Earth. (Celestron 11-inch Schmidt-Cassegrain, SBIG ST-5C CCD camera, December 24, 2002) DAMIAN PEACH


south polar region
south south temperate zone
south south temperate belt
south temperate zone
south temperate belt
south tropical zone
south equatorial belt
equatorial zone south
equatorial band
equatorial zone north
north equatorial belt
north tropical zone
north temperate belt
north temperate zone
north north temperate belt
north north temperate zone
north polar region


C ring
B ring
A ring
F ring
Encke Division
Cassini Division

THREE IMAGES OF SATURN show its rings at their maximum tilt, providing us with our best view. Note the subtle coloration differences in the equatorial region of Saturn's globe. (Celestron 14-inch Schmidt-Cassegrain telescope at f/27, SBIG ST-5C CCD camera, October 1, 2002, at 10h42m UT [top], October 4, 2002, at 11h19m UT [right], and November 23, 2002, at 07h52m UT [bottom]) ED GRAFTON

do not necessarily appear the same throughout an apparition. Observers are encouraged to estimate the "intensity" of belts, zones, and other discrete phenomena and to record how their intensity varies over time. The ALPO Saturn Section employs a numerical relative intensity scale ranging from 0.0 (black shadows) to 10.0 (brilliant white). If you're observing without a filter, use the outer third of the B ring as the "standard." Its intensity is defined as 8.0, and it does not fluctuate appreciably. With practice, values obtained by this method are quite accurate.

Intensity estimates of belts and zones made while using color filters are valuable for monitoring the prominence of atmospheric features in different wavelengths. Blue filters (W47 or W38A) and red filters (W25 or W23A) boost the prominent bluish and reddish areas on Saturn, respectively. A yellow-green filter (W57) improves contrast by darkening both

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Julius L. Benton, Jr., *is coordinator of the Saturn Section for the Association of Lunar and Planetary Observers.*

bluish and reddish areas. A magenta filter (W30) is considered the "universal color filter" because it transmits red and blue wavelengths while suppressing green light, thereby increasing the threshold visibility of very low contrast markings.

The ring system

The broad rings encircling the globe of Saturn are responsible for the planet's exquisite beauty and popularity. Through a medium-size telescope, it is easy to see the rings are subdivided into three main components of varying brightness. The outermost of these is the A ring. It is separated from the brighter, central B ring by a dark gap called the Cassini Division, which is visible in a 3-inch telescope. The innermost of the major ring components is the C ring, by far the faintest of the three, requiring apertures in excess of 4 inches. Halfway between the outer and inner edges of the A ring is the Encke Division, and eight-tenths of the way out from the globe in the A ring is the very narrow Keeler Gap.

In addition to these main divisions, regular Saturn observers have reported, for many years, at least four or five "intensity minima" near the threshold of vision in the ring components. And, although the two Voyager spacecraft that flew by Saturn in 1979 and 1980 revealed the rings are composed of multitudes of minor gaps that vary in location and conspicuousness, amateur astronomers were the first to argue for decades that the Cassini and Encke divisions were not the only such features in the rings.

Well before the Voyager flybys, amateurs also sighted the E ring, a tenuous ring external to the A ring, and they recorded the earliest visual observations of a remarkable series of radial, dusky "spokes" in the B ring during the 1956–1957 apparition. Since then, these curious features have been observed sporadically by amateur astronomers up to and after the confirmation by Voyager that they were not mere optical illusions.

Saturn's axis of rotation is tilted to the pole of its orbit by about 27°, and consequently, it has seasons like Earth, albeit longer in duration. As Saturn orbits the Sun every 29.5 years, the inclination of the ring system to our line of sight varies between 0° and ± 27° during periods of 13.75 years and 15.75 years. The two intervals are unequal because Saturn's orbit around the Sun is elliptical. The 2003–2004 apparition occurs during the shorter 13.75-year period, when Saturn passes through perihelion (its closest approach to the Sun).

When Saturn reaches opposition this December, its rings will be tilted 25.5°, with the south edge facing Earth. Observers should not miss this opportunity to study the south face of the rings closely because, with each passing year, the rings will be less inclined until they reach edgewise orientation in August 2009.

The observational methods used when studying Saturn's global features can be applied to the rings. Observers should make visual numerical intensity estimates of ring components and divisions in unfiltered light and with color filters.

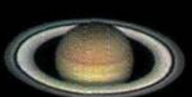
Drawings of the rings should be made at the same time observers are sketching the globe. The ALPO Saturn Section has prepared a series of drawing blanks depicting the tilt of the ring plane for many dates. For the current apparition, use the blanks for values of –24° to –26°. Outlines of the A ring, the B ring, and the Cassini Division already appear on the blanks. Simply sketch in the C ring, plus other divisions or intensity minima. Also, depict phenomena such as spokes and discrete features.

Observers have found that seeing the Encke Division requires an aperture of about 8 inches, and the Keeler Gap is within reach of 10-inch instruments. The C ring is visible through a 3-inch telescope, but larger apertures will help observers identify any variations in tone within this dark ring component.

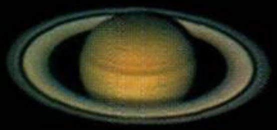
Occultations by Saturn

When stars of sufficient brightness lie in Saturn's path during an apparition, it is possible for observers to see them occulted by the rings. At such times, observers are confronted with rare opportunities for detecting and measuring locations of intensity minima in the rings. Such minima appear as darker areas where stars may be seen during occultations. Variations in the magnitudes of stars as they pass behind the rings can reveal intensity differences that otherwise would not be seen.

Unfortunately, during an occultation only fairly bright stars can be observed with smaller telescopes. For example, a 7th magnitude star occulted by the A ring may

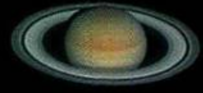


A BRIGHT STORM ON SATURN was imaged on December 22, 2002, at 06h00m UT. Located at –42° latitude (upper center), the storm was the largest in a series of storms observed over a month's time. (Celestron 14-inch Schmidt-Cassegrain telescope at f/27, SBIG ST-5C CCD camera) ED GRAFTON

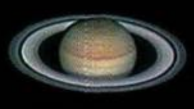


SATURN'S SOUTH EQUATORIAL BELT is split into two parts, one much darker. (10-inch Takahashi Mewlon 250 at f/27, Phillips ToUcam Pro webcam, January 20, 2003, at 15h40m UT) TAN WEI LEONG

THE RINGED PLANET may appear tilted depending on where it is in the sky. (11-inch Celestron Schmidt-Cassegrain, SBIG ST-5C CCD camera, December 24, 2002) DAMIAN PEACH



A SPOT IN SATURN'S TEMPERATE ZONE, nearly on the Central Meridian, is about 1" in size and has very low contrast. Spots like this are rare, and observers are encouraged to monitor them. (14-inch Celestron Schmidt-Cassegrain telescope at f/27, SBIG ST-5E CCD camera, September 29, 2002) ED GRAFTON



COMPARE THIS SPOT in Saturn's south temperate zone to the spot in the image immediately above. Observers in late 2002 saw several such spots (14-inch Celestron Schmidt-Cassegrain telescope at f/27, SBIG ST-5 CCD camera, November 20, 2002, at 08h43m UT) ED GRAFTON be seen with difficulty through a 6-inch telescope, while an 8th-magnitude star might not be detected with anything less than a 12-inch aperture. Although no bright stars are predicted to be occulted by the rings of Saturn during this apparition, mention of this important project is made here for future consideration.

Saturn's satellites

Of Saturn's thirty-plus known satellites, only about eight have significance to observers. Mimas, at visual magnitude 12.1, is the faintest of these. It's difficult to find because it lies close to Saturn, so seeing Mimas requires a large aperture. Enceladus, at visual magnitude 11.7, fluctuates in brightness and is quite difficult to detect with anything less than a 10-inch telescope. Tethys and Dione are both near visual magnitude 10.6 and can be seen through a 4-inch telescope when they're far from Saturn's globe. Rhea, at visual magnitude 10.0, is easy to see using a 3-inch telescope and may exhibit brightness variations. The brightest moon, reddish Titan, at visual magnitude 8.3, can be viewed through a 2.4-inch instrument.

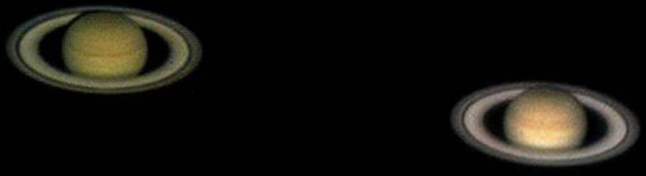
Perhaps the most interesting saturnian satellite is Iapetus. Its visual magnitude ranges from 9.0 to 10.8, depending on where it is in its orbit around Saturn. From Voyager data, we know that one face of Iapetus is very bright and the other is quite dark, which is the reason for the great variance in brightness. Observers can see Iapetus through a 3-inch telescope when the moon is at its brightest.

An observing project

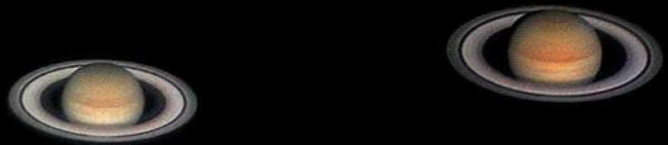
A fun project observers might try is to visually estimate the brightness of Saturn's satellites. Compare them with standard reference stars in the same way observers make estimates of variable stars. Estimating the magnitude of a moon is a bit more complicated because the apparent brightness of a satellite is a function of its distance from Saturn's brilliant globe and the moon's actual brightness.

Whichever observing program you follow, even if it's only a casual look every now and then, Saturn will not disappoint you. Its atmosphere, moons, and glorious ring system offer countless hours of fun at the eyepiece.

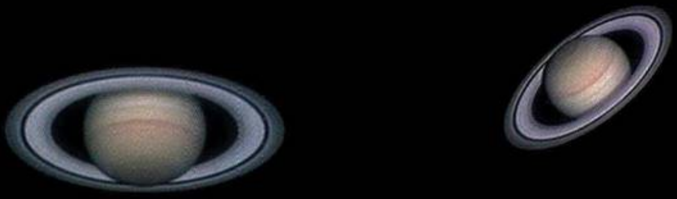
To learn more about Saturn, visit www.astronomy.com/toc



TWO VIEWS OF SATURN THROUGH DIFFERENT TELESCOPES show subtle differences. The image to the left was taken through a 10-inch Takahashi Mewlon 250 at f/27 on January 15, 2003, at 14h35m UT. The image to the right was taken through an 11-inch Celestron Schmidt-Cassegrain telescope on December 18, 2002, at 17h24m UT. Both were recorded by a Phillips ToUcam Pro webcam. TAN WEI LEONG



THE CREPE RING OF SATURN is a difficult feature to observe through small telescopes. Also known as the C ring, it is the innermost ring seen in this pair of images. The globe of Saturn can be seen through the Crepe ring, taking on a dusky quality. (14-inch Celestron Schmidt-Cassegrain telescope at f/68, SBIG ST-6 CCD camera, taken September 30, 2002, at 10h05m UT [left] and November 19, 2001, at 06h39m UT [right]) ED GRAFTON



SATURN UNDER EXCELLENT SEEING CONDITIONS is an amazing sight. Both images above show many fine belts and zones, a small spot in the south tropical zone, and details across the ring system including the Encke Division. Mr. Peach reported superb views on both occasions using magnifications of 600x and higher. (12-inch Meade Schmidt-Cassegrain telescope, SBIG ST-5E CCD camera, taken December 24, 2002 [left], and October 22, 2002 [right], from Puerto de la Cruz, Tenerife, Canary Islands) DAMIAN PEACH

INTENSITY MINIMA IN SATURN'S RINGS can be seen in this image as faint, low-contrast "divisions" in the B ring. (14-inch Celestron Schmidt-Cassegrain telescope at f/68, SBIG ST-6 CCD camera, taken on October 18, 2001, at 08h52m UT, from Houston, Texas) ED GRAFTON

SATURN'S COLORS ARE MUTED but distinct. Note the south polar region is brownish and has a greenish "collar." (11-inch Celestron Schmidt-Cassegrain telescope at f/23, Phillips ToUcam Pro webcam, taken January 1, 2002, from Singapore) TAN WEI LEONG

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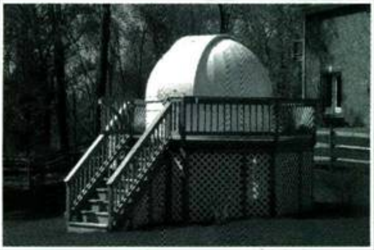

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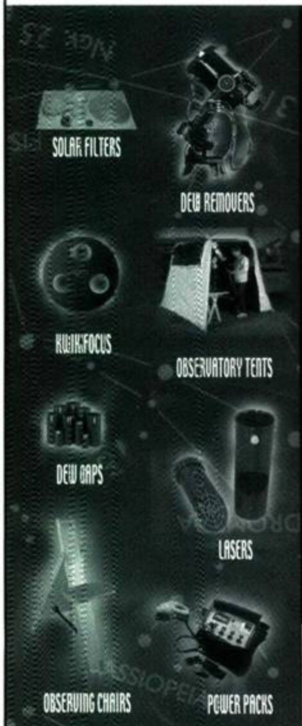

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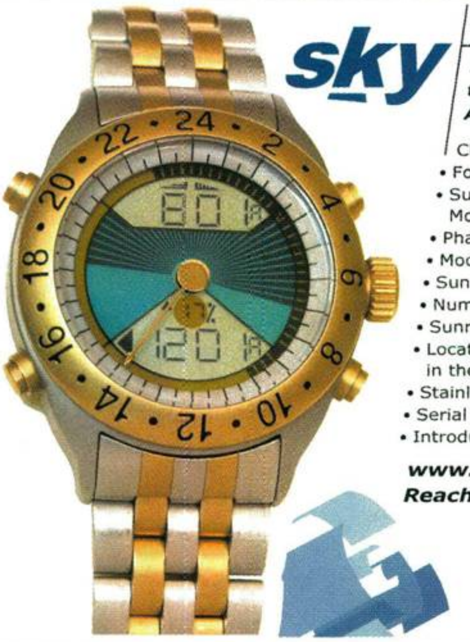

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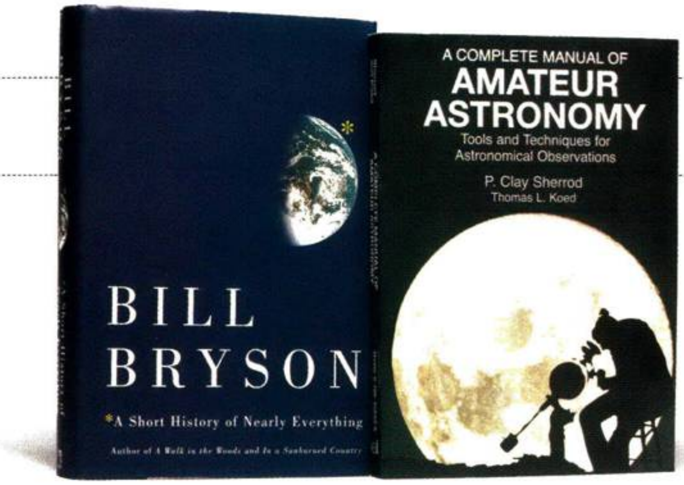
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A Short History of Nearly Everything

Bill Bryson, 560 pages, Broadway Books, New York, 2003; ISBN 0-7679-0817-1; hardcover, $27.50.

In the spirit of Albert Einstein, one of the characters in Bill Bryson's latest offering, this title is relative. *A Short History of Nearly Everything* is anything but short, and it hardly covers "nearly everything." But for those who love to read (and read and read), Bryson, who is better known for his humorous travel writing, delivers a clear history of a number of sciences.

Bryson's *Short History* is nothing less than ambitious. A more cautious writer, exploring what amounts to a new genre at the peak of his popularity, might be tempted to limit such an undertaking to one topic. Bryson packs astronomy, physics, chemistry, geology, evolutionary biology, and more into one comprehensive text.

Readers fond of Bryson's keen eye for atmospheric detail won't be disappointed: He vividly describes the overdue eruption of a "colossal volcanic hot spot" at Yellowstone National Park and the objects that careen across the "freeway" of Earth's orbit.

Beginning with the Big Bang, he establishes humanity's insignificance within time and space, a consistent theme throughout the text. He depicts, for example, an incredible 10,000-year journey to the far reaches of the solar system, through the heart of the theorized Oort comet cloud.

Entertaining and accessible, the book showcases Bryson's gift for simplifying the sometimes overwhelmingly complicated, such as relativity and DNA. He includes some detailed, if tangential, historical and biographical interludes. In addition to Einstein, some of the more notable personalities include Edwin Hubble and Charles Darwin. While this may seem a bit cliché (biographical treatments of these figures saturate the market), Bryson tends to fixate on some of the more obscure, and often unflattering, details. He calls Hubble an "inveterate liar" and presents Darwin's view of himself as the "devil's chaplain."

Bryson writes with confidence. Readers familiar with his previous work, notably *A Walk in the Woods*, will recognize his need to express himself through absolutes. Often skirting the boundaries of arrogance, he unfortunately lacks the authority of writers such as Timothy Ferris, John Horgan, or John Gribbin, who have devoted their careers to science. To compound this shortcoming, Bryson uses the odd quote taken out of context to criticize those with true authoritative clout. Readers who appreciate more meticulous research may find this disappointing. — **STEPHEN SNYDER** *teaches writing at Berks-Lehigh Valley College, part of Pennsylvania State University.*

A Complete Manual of Amateur Astronomy: Tools and Techniques for Astronomical Observations

P. Clay Sherrod and Thomas L. Koed, 319 pages, Dover Publications, Mineola, New York, 2003; ISBN 0-4864-2820-6; softcover, $18.95.

"It is not the instrument but the person who uses it who unravels the mysteries of the skies." So wrote Clay Sherrod in his pitch to the hobbyist who might be wondering what comes after Messier's list.

Caldwell and Herschel notwithstanding, astronomy's appeal to the amateur is the opportunity to stand alongside the professional on the verge of discovery. To do so, amateurs must learn the methodology for compiling data, and that is where beginner books sign off and this manual signs on.

Scientific tutorials have the potential to be as clear as mud and as dry as desert dust, but the conversational style of this narrative and its orderly presentation impressed me. Simple, elegant diagrams and easy formulae make the measurement of a comet's tail a piece of cake. This work is totally without filler: Each morsel of experience — be it fact, suggestion, or potential pitfall — is relevant and ideally placed. And even if you never submit a variable star report, the book will make you a more knowledgeable observer.

To be fair, you should know that Dover has reprinted this 1981 release without updating it. Fortunately, the techniques described for collecting and reducing data apply equally well today. While optics have evolved, the equipment suggestions remain valid. In fact, Thomas Koed's contributions on SLR astrophotography and the polar alignment of equatorial mounts are thorough enough to see most film buffs through the night.

By the authors' own admission, some areas receive little or no attention. Most obvious is the virtual lack of double star coverage — the topic gets only brief mention in a chapter on lunar occultations. While the section on transit timing is top-notch, the focus is on craters and planetary features as opposed to the Jovian moons or the rare but important trips across the Sun by Venus and Mercury.

Appendices include projects to get you started and submission forms to research groups such as the American Association of Variable Star Observers. Whether you want to contribute to science or just improve your skills, this guide will help you get the most from your scope. It may not cure aperture fever, but for the price, it's a darn good remedy. — **GLENN MULLER** *still hopes tools will improve his technique as he observes from Grimsby, Ontario, Canada.*

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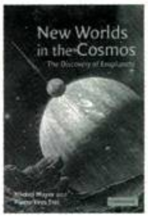

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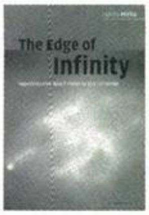

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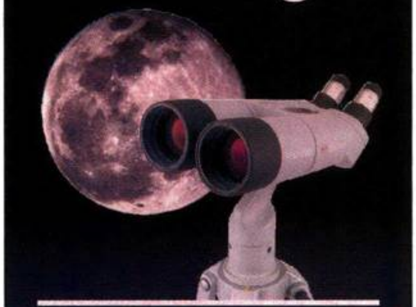

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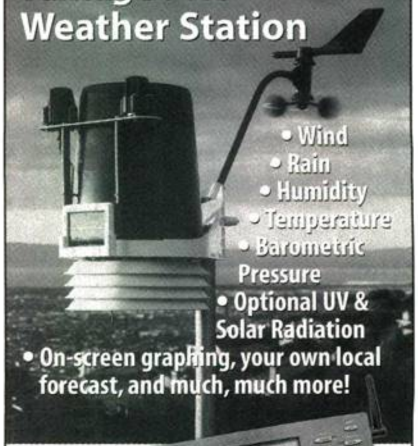

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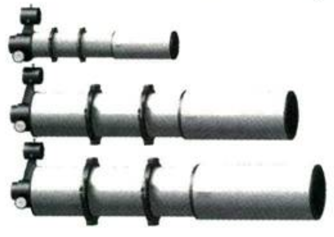

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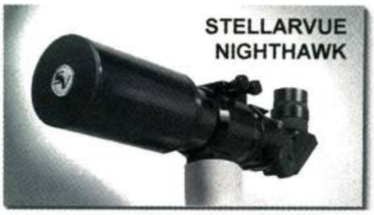

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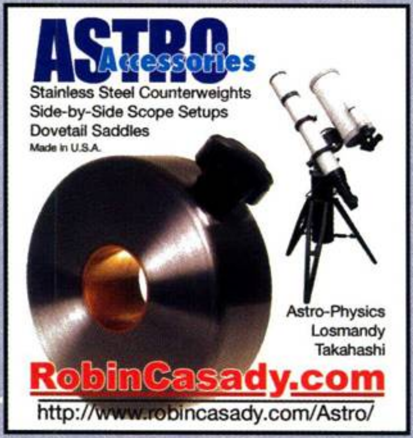
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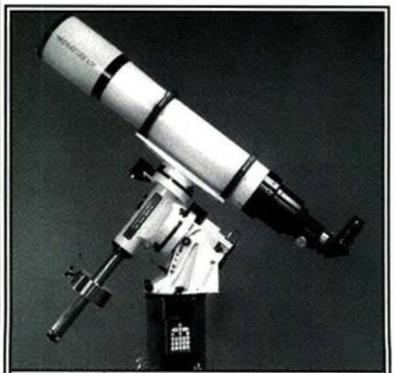
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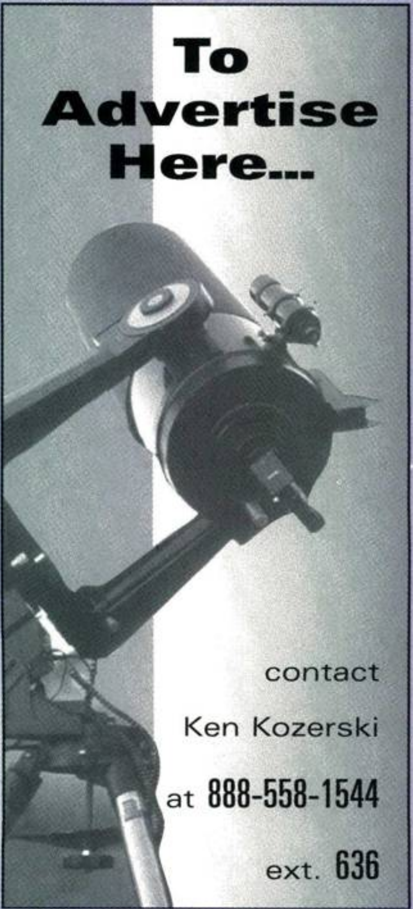
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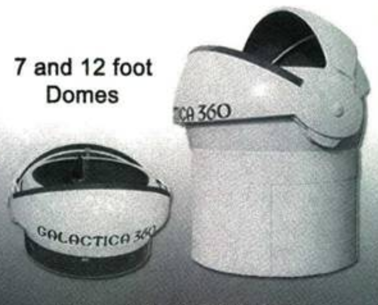

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01.03.04–01.11.04

After their long journeys, the twin Mars rovers, Spirit and Opportunity, are scheduled to arrive at the Red Planet in early January. To mark the dual landings, the Exploratorium in San Francisco is hosting "Landing on the Red Planet." Through daily live updates, visitors will see amazing images sent by the rovers, and they'll be able to speak with scientists and engineers about all aspects of Mars exploration.

A REPLICA OF THIS ROVER will be on display throughout January at the San Francisco Exploratorium as part of an exhibit recognizing the Mars Exploration Rover Mission. JPL

Live updates are just part of *Exploring Mars*, a month-long exhibit recognizing NASA's Mars Exploration Rover (MER) Mission. Some of the highlights at the Exploratorium include a full-size MER replica, visitor-controlled robotic insects on replicated martian terrain, films, and a 15-foot egg drop contest used to simulate the rovers' airbag landings.

For more information and a full schedule of events, call 415.561.0360 or visit www.exploratorium.edu/marsrover.

01.02.04–01.04.04

Planetfest '04

Pasadena Convention Center, Pasadena, California. The Planetary Society will celebrate space exploration with activities ranging from watching a live feed from NASA's mission control to meetings and lectures with former astronauts, space scientists, and science fiction writers. While organizers anticipate 10,000 people will attend in person, millions of others around the world will join in via web casts. For more information, visit www.planetary.org/planetfest04.

01.04.04–01.08.04

American Astronomical Society Meeting

Hyatt Regency, Atlanta. At the 1913 American Astronomical Society (AAS) meeting in Atlanta, Henry Norris Russell delivered a lecture that helped lead to the widespread use of the Hertzprung-Russell diagram to interpret the characteristics of stellar clusters. Nearly ninety years later, the AAS gathers again in Atlanta with Russell's momentous talk in mind. This 203rd meeting of the AAS will feature lectures, discussions, and special events. For more information, visit www.aas.org.

01.23.04–01.24.04

Furnace Creek Inn Star Party

Furnace Creek Inn and Ranch Resort, Death Valley, California. The Las Vegas Astronomical Society will coordinate the daytime and nighttime observing at this star party. Other activities include lectures, horseback riding, golf, and hiking. For more information, contact Phyllis at 760.786.3353; web site, www.furnacecreekresort.com.

01.24.04–01.25.04

Connaught Star Party

Westwood House Hotel, Galway City, Galway, Ireland. This star party commemorates the 5th anniversary of the Galway Astronomy Club. For more information, e-mail galwayastro@email.com; web site, homepage.eicom.net./~galwayastronomyclub.

02.07.04–02.08.04

European Astrofest

Kensington Town Hall, London, England. Celebrating its 11th year, European Astrofest will feature workshops, commercial exhibitors, and many speakers. *Astronomy* editor Dave Eicher will attend and lecture on planetary nebulae and other deep-sky wonders. For more information, visit www.astronomynow.com/astrofest.

02.12.04–02.16.04

American Association for the Advancement of Science Annual Meeting

Washington State Convention and Trade Center and the Sheraton Seattle Hotel and Towers, Seattle. The theme of this year's annual meeting is "Science at the Leading Edge." This AAAS gathering will examine all disciplines of science. For more information, visit www.aaas.org.

02.12.04–02.16.04

Workshop on Europa's Icy Shell: Past, Present, and Future

Center for Advanced Space Studies, near NASA's Johnson Space Center, Houston. This Lunar and Planetary Institute's meeting will provide an opportunity for planetary scientists and astronomers to discuss the current understanding of Europa's icy shell, its physical state and evolution, and its interaction with the putative subsurface ocean. For more information, visit www.lpi.usra.edu/meetings/europa2004.

02.16.04–02.21.04

Winter Star Party

Camp Wesumkee, West Summerland Key, Florida Keys, Florida. Sponsored by the Southern Cross Astronomical Society, the Winter Star Party celebrates its 20th annual gathering. *Astronomy* associate editor Maggie McKee will be in attendance for the second straight year. For more information, visit www.scas.org.

02.18.04–02.22.04

Orange Blossom Special Star Party

Hickory Hill Observing Complex, near Brooksville, Florida. Highlights of the Orange Blossom Special will include daytime and nighttime observing, lectures, a swap table, door prizes, a music jam session, and a special youth program. For more information, visit home1.gte.net/hoffmanc/index.html.

05.16.04–05.23.04

Texas Star Party

Prude Ranch, near Fort Davis, Texas. The "observer's environment" and dark skies will bring serious amateur astronomers back for this 26th annual event. Guests will be selected through a random drawing in late January. For more information, contact the TSP Registrar at 512.451.8895 (day) or 512.451.0339 (evening); e-mail, tspreg@metronet.com; web site, www.texasstarparty.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

Learn more about this issue's topics:

JOURNEY TO SATURN

BOOKS — Any good book on the solar system contains plenty of material on Saturn, its rings, and its moons. One of the best is *The New Solar System*, 4th edition, edited by J. Kelly Beatty, et al. (Cambridge University Press, 1999).

ARTICLES — For all the details about Cassini's flyby of Jupiter in late 2000 and early 2001, check out Richard Talcott's article "A giant awakens Cassini" (*Astronomy*, April 2001).

WEB — The official web sites of Cassini and Huygens are the best sources for news on each component's progress. NASA's site, which concentrates on the Cassini orbiter, resides at saturn.jpl.nasa.gov/index.cfm. The European Space Agency's site for the Huygens probe is located at sci.esa.int/science-e/www/area/index.cfm?fareaid=12. In addition to the latest news, each agency provides background information on its respective mission.

IN THE LINE OF FIRE

ARTICLES — Pennsylvania State University astronomer Peter Mészáros has written several excellent review articles on GRBs. In particular, see "The supernova connection" (*Nature*, vol. 423, June 19, 2003) and "Theories of Gamma-Ray Bursts" (*Annual Review of Astronomy and Astrophysics*, vol. 40, 2002). Astronomers Stan Woosley, Weiqun Zhang, and Alexander Heger discussed "The Central Engines of Gamma-Ray Bursts" in *Gamma-Ray Burst and Afterglow Astronomy 2001: A Workshop Celebrating the First Year of the HETE Mission* (American Institute of Physics, Melville, New York, 2003).

WEB — For a general introduction to GRBs, visit imagine.gsfc.nasa.gov/docs/science/know_l1/bursts.html. View animations of a GRB–supernova event at www.gsfc.nasa.gov/topstory/2003/0618rosettaburst.html. And visit astronomer Andrew Fruchter's images of GRB host galaxies at www-int.stsci.edu/~fruchter/GRB.

SPACE FLIGHT IS UTTER BILGE

BOOKS — In the 1950s, a number of books aimed at the public were published to promote the idea of space travel. Several of the best are *Across the Space Frontier* by Joseph Kaplan, Wernher von Braun, et al. (Viking, New York, 1952), *The Conquest of Space* by Willy Ley (Viking, New York, 1952), and *The Conquest of the Moon* by Wernher von Braun, et al. (Viking, New York, 1953). These titles turn up fairly often in used bookstores and also may be available through on-line booksellers.

Several recent books that examine how the idea of space flight penetrated the consciousness of the American public include: *The Dream of Spaceflight* by Wyn Wachhorst (Basic Books, New York, 2000) and *Rocket Dreams* by Marina Benjamin (Free Press, New York, 2003).

WEB — NASA has an excellent history site at history.nasa.gov, and the Encyclopedia Astronautica, www.astronautix.com, covers a wide range of subjects and periods.

HEAVEN ON EARTH

WEB — Visit www.astronomy.com/content/static/trips for more information on upcoming *Astronomy* tours.

For a tempting look at the accommodations in Chena, Alaska, see the Chena Hot Springs Resort's web site at www.chenahotsprings.com. The National Oceanic and Atmospheric Association regularly takes measurements of the charged particles that cause aurorae: see up-to-date maps of where aurorae likely are visible at www.sec.noaa.gov/pmap/index.html.

If wild horses couldn't drag you to the cold climes of Alaska in winter, consider a trip to Hawaii. Check for programs and weather at the Visitor Information Station on Mauna Kea at www.ifa.hawaii.edu/info/vis/index.html. Visit the Office of Mauna Kea Management's site at www.malamamaunakea.org/site/index.php to find links to the mountain's telescopes and information on Hawaiian culture.

LUNAR APENNINES

BOOKS — An outstanding and profusely illustrated survey of lunar geology is Don E. Wilhelms's *The Geologic History of the Moon* (U.S. Geological Survey Professional Paper 1348, Washington, D.C., 1987). For a hands-on approach, check out *The Moon: An Observing Guide for Backyard Telescopes* by Michael Kitt (Kalmbach Publishing, Waukesha, Wisconsin, 1992).

Plan your observing sessions with *Atlas of the Lunar Terminator* by John E. Westfall (Cambridge University Press, New York, 2000). Images in this book are oriented north-up, opposite the view through a telescope, but their arrangement follows the terminator throughout the month.

WEB — The United States Geological Survey (USGS) web site is a treasure trove of information: Find names and locations of lunar features at planetarynames.wr.usgs.gov/moon/moonTOC.html; geological maps of the Moon are located at astrogeology.usgs.gov/Projects/PlanetaryMapping/DIGGEOL/moon.htm.

SATURN IN PRIME TIME

BOOKS — A book now out of print but not difficult to find — and well worth the effort — is *Imaging Saturn: The Voyager Flights to Saturn* by Henry S. F. Cooper (Henry Holt, New York, 1983). A new, very advanced book that discusses the science of all four gas giants (Jupiter, Uranus, Neptune, and Saturn) is *Giant Planets of Our Solar System: Atmospheres, Composition, and Structure* by Patrick Irwin (Springer Verlag, New York, 2003).

WEB — A site with lots of information and images may be found at www.the-planet-saturn.com. Another excellent resource is "The Nine Planets" page at seds.lpl.arizona.edu/nineplanets/nineplanets/saturn.html. Maintained by the Students for the Exploration and Development of Space (SEDS), this web site has links to many Saturn-related sites covering everything from history to space missions.

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E. Free distribution outside the mail (carriers or other means)	280	400
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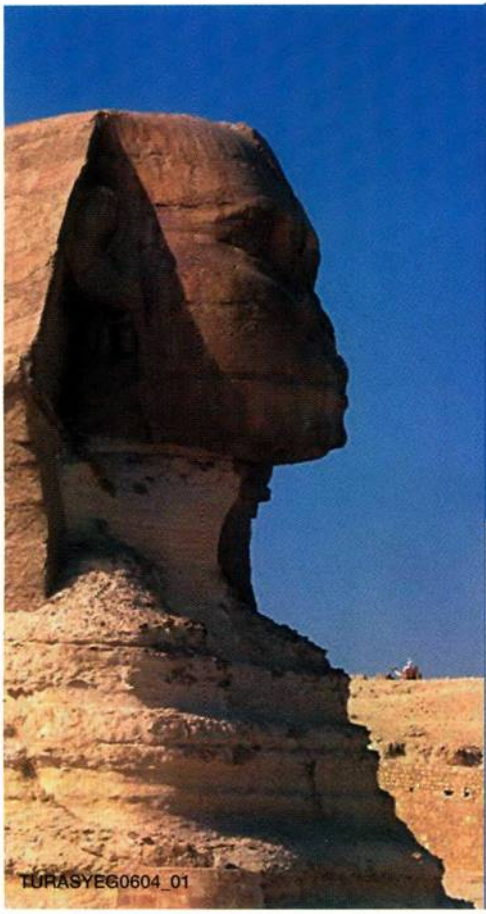

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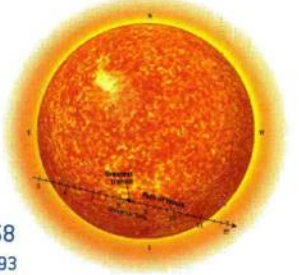

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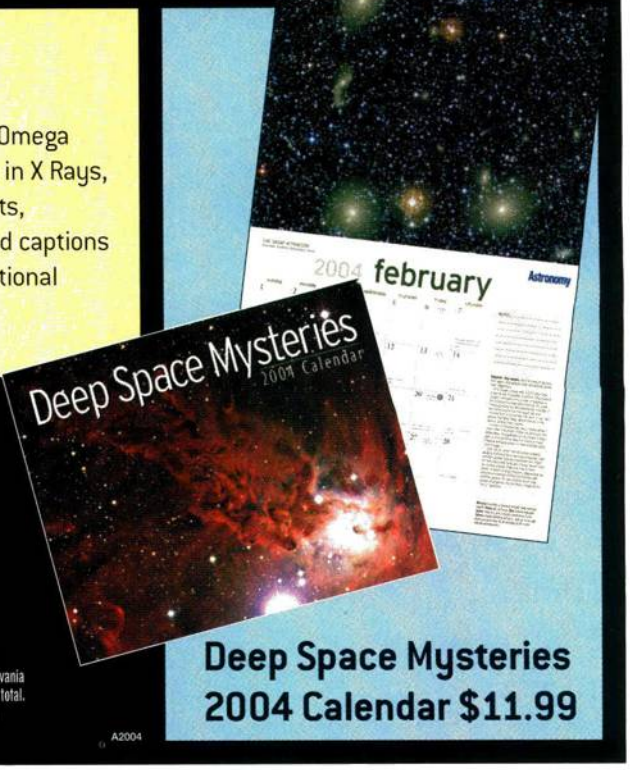

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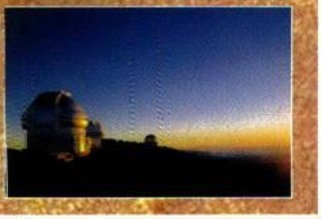

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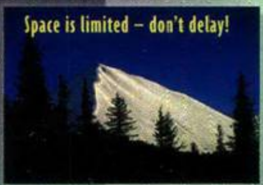
March 12-20, 2004

Astronomy magazine



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Alaskan aurora photograph by Mike O'Leary

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Reader gallery

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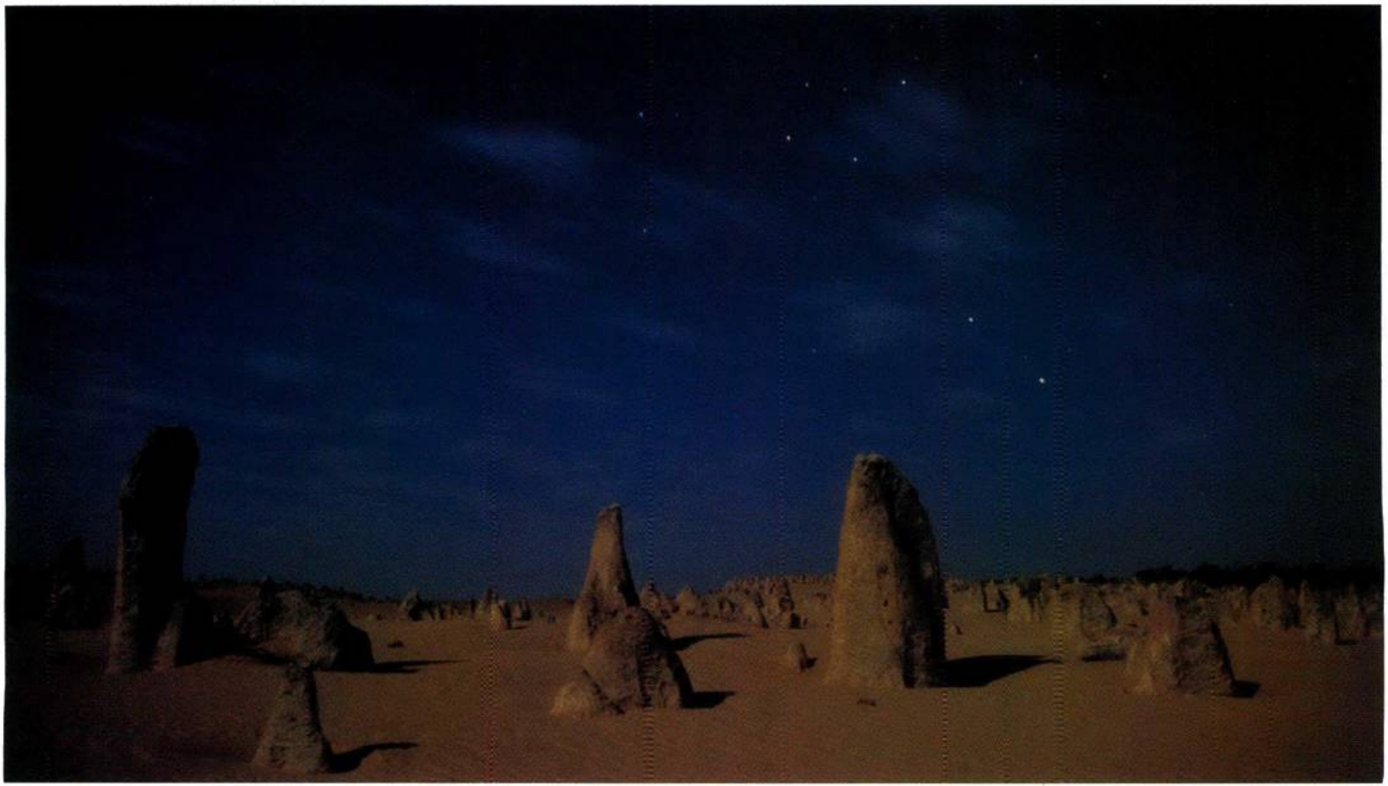
Southern stars /// Asteroid crosses M8 /// Copernicus crater /// Planetary nebulae
Spiral and interacting galaxies /// Open cluster M38 /// Star trails over Yerkes Observatory

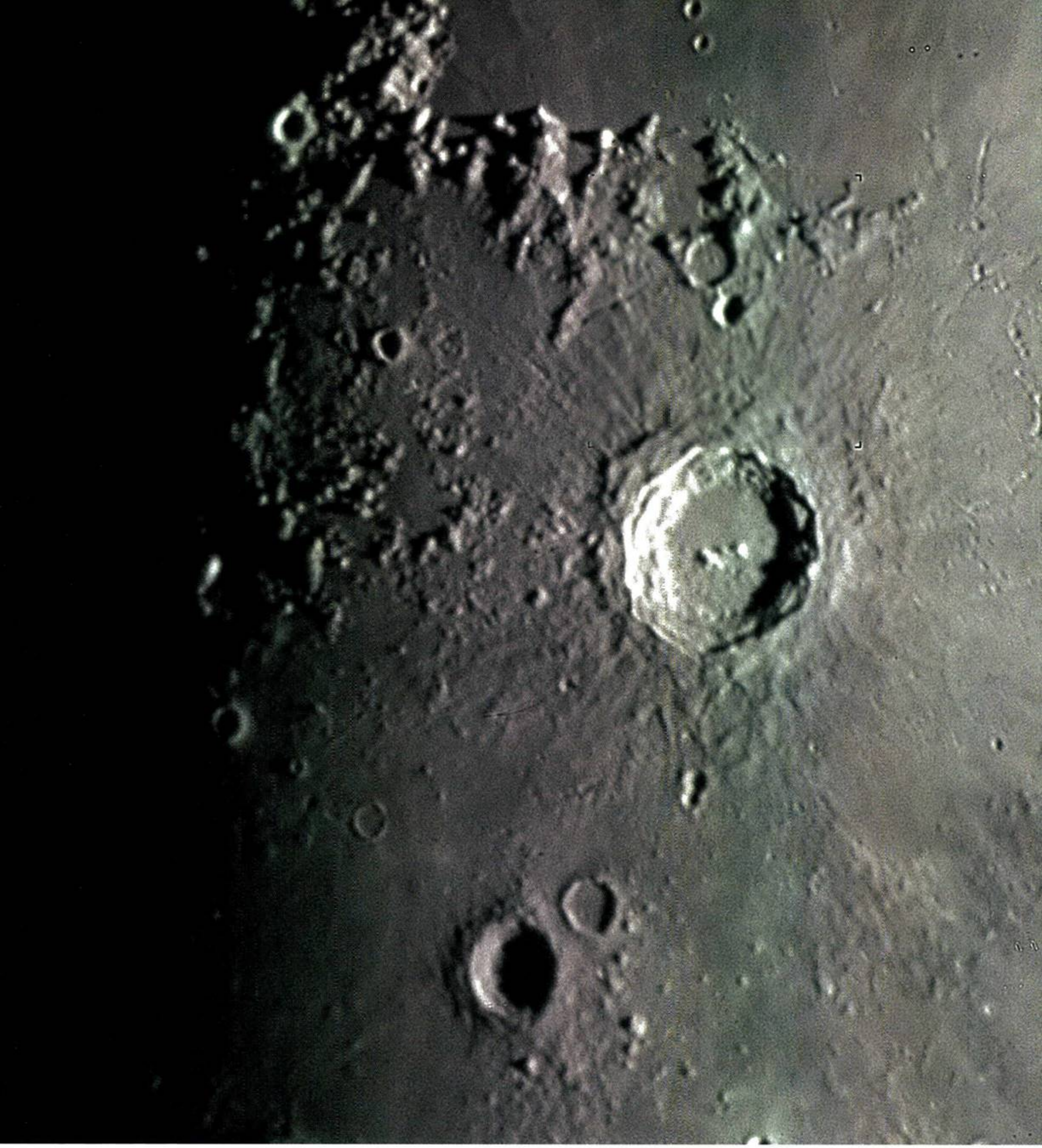


Above, **ALPHA AND BETA CENTAURI RISE WITH THE SOUTHERN CROSS** [28mm lens at f/4, Ektachrome 1600 film, taken September 3, 2003, in Nambung National Park, Australia] /// **FABRIZIO MELANDRI**

THE SOUTHERN SKY

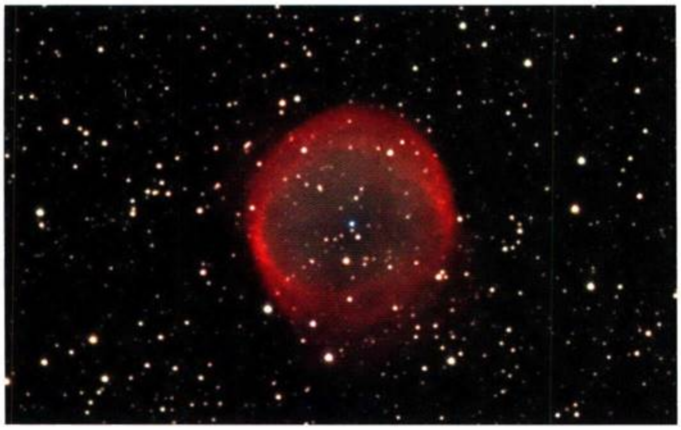
What a difference a hemisphere makes

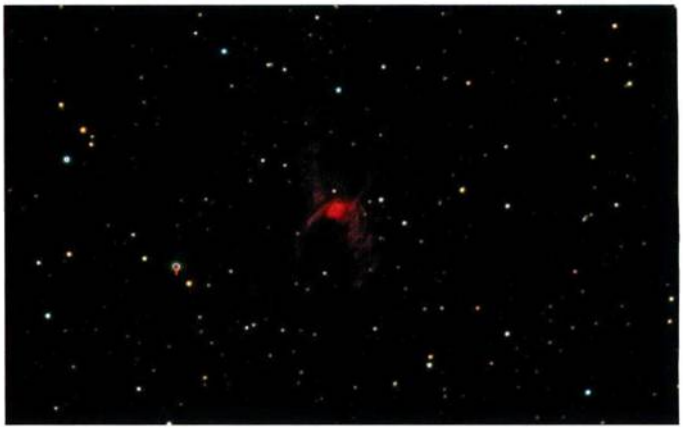
At *Astronomy*, we're often asked about the differences between the sky seen in the Northern Hemisphere (above the equator) and the Southern Hemisphere (below the equator). A few things come to mind: Different stars can be seen in each hemisphere, although many can be seen from both; there's no "South Star" above the south pole corresponding to Polaris, the North Star; the southern sky has more bright stars overall; and the two satellite galaxies of the Milky Way, the Large and Small Magellanic Clouds, are seen easily. Perhaps the most interesting difference noticed by observers is that in the Southern Hemisphere the stars go "the wrong way" when they rise. Instead of making paths to the upper right, as most readers of *Astronomy* are accustomed to, stars follow lines that curve to the upper left. This difference is due to the position of the celestial poles in each hemisphere.

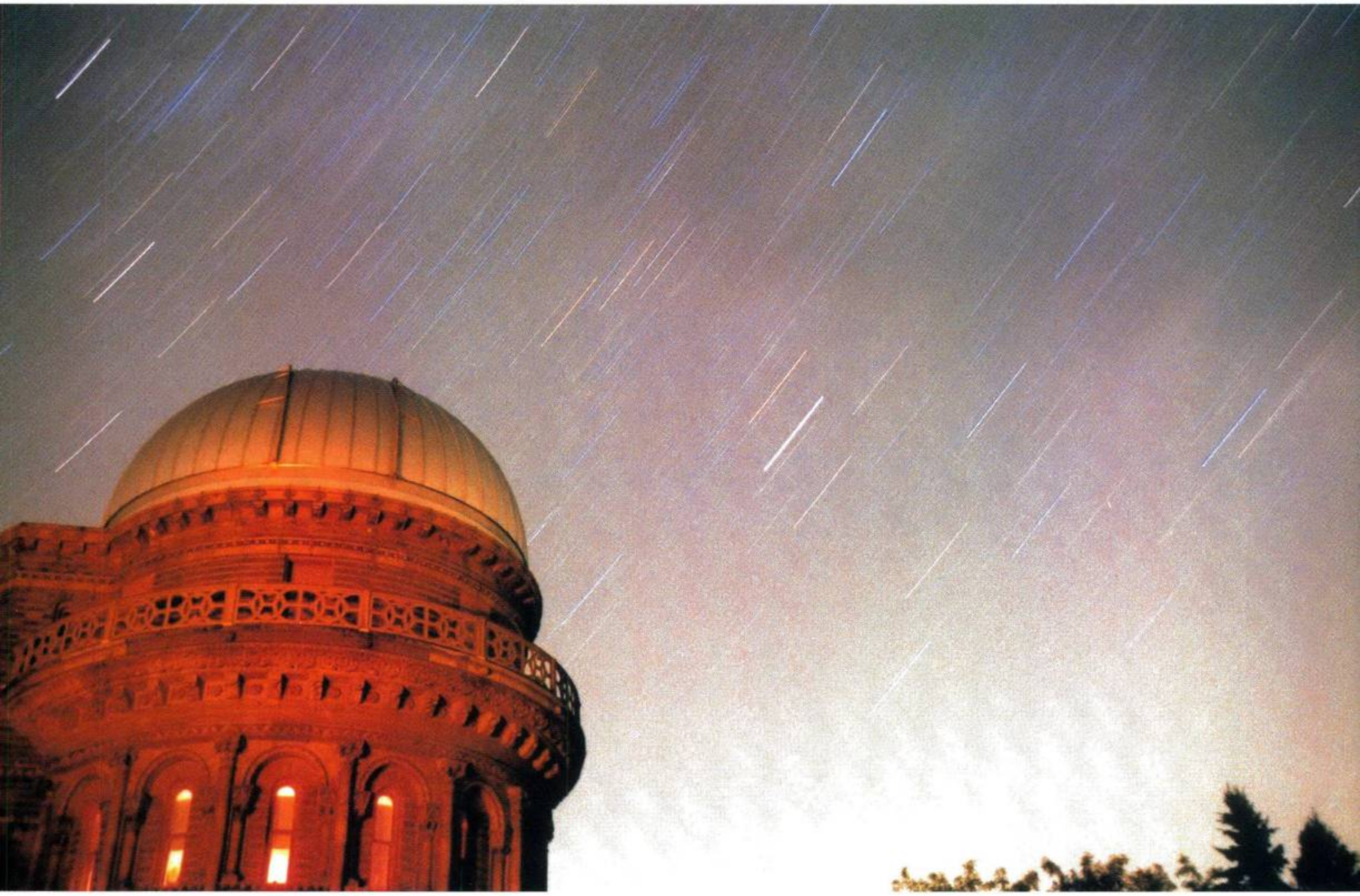


Above, **LUNAR CRATER COPERNICUS** (11-inch Celestron Schmidt-Cassegrain telescope, 2x Barlow lens, Philips ToUcam Pro video camera, the best 50 of 600 frames were combined into the final image, taken May 2, 2003, from De Bilt, Netherlands) /// **JOHN SUSSENBACH**

Send photos to: ASTRONOMY Reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.





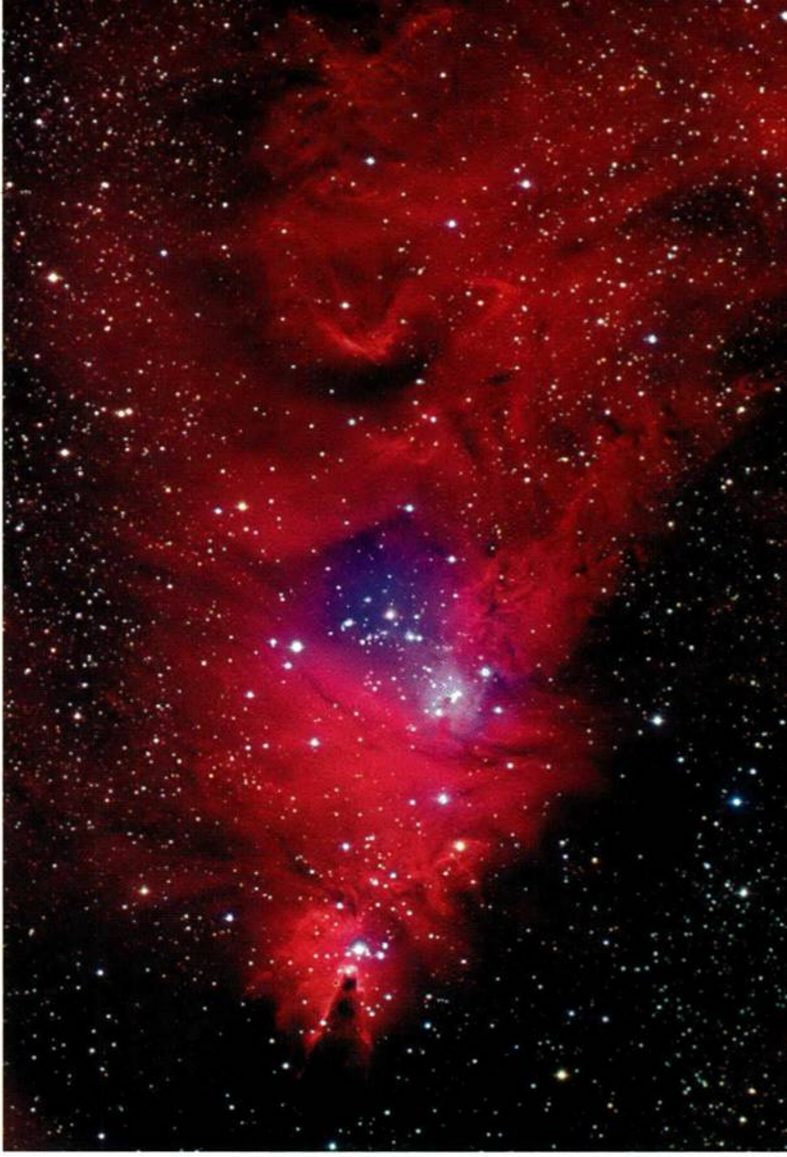


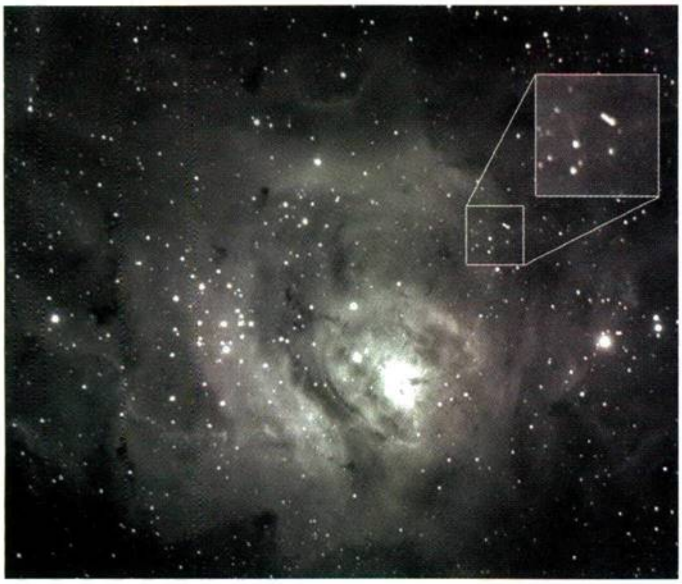
Top left. **PLANETARY NEBULA NGC 6781 IN AQUILA** (Optical Guidance Systems 20-inch Ritchey-Chrétien at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 60, 10, 10, and 10 minutes, respectively) /// **ADAM BLOCK**

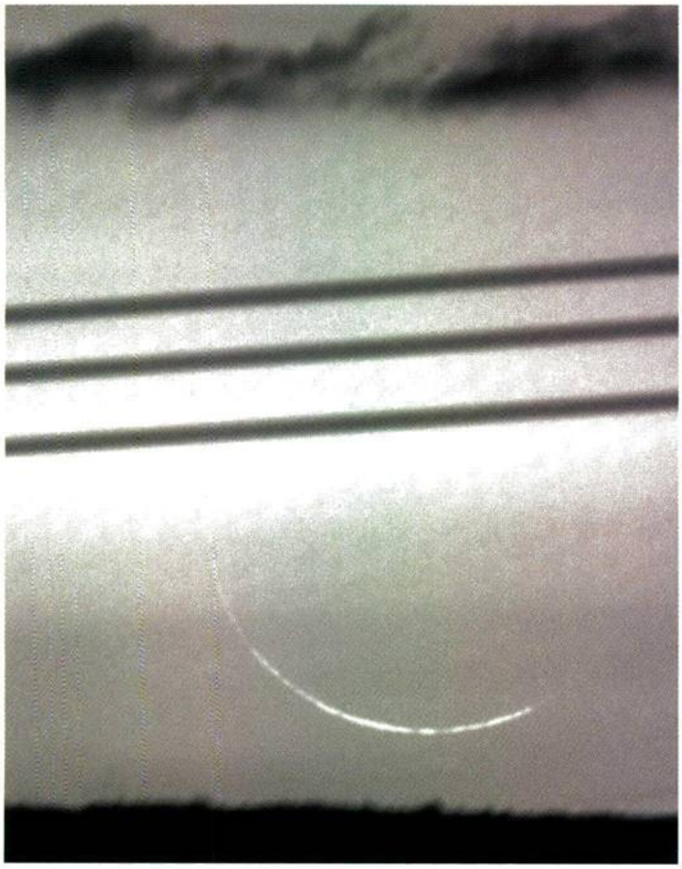
Top right. **THE RED SPIDER (NGC 6537) PLANETARY NEBULA IN SAGITTARIUS** (Optical Guidance Systems 20-inch Ritchey-Chrétien at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 75, 10, 20, and 20 minutes, respectively) /// **ADAM BLOCK**

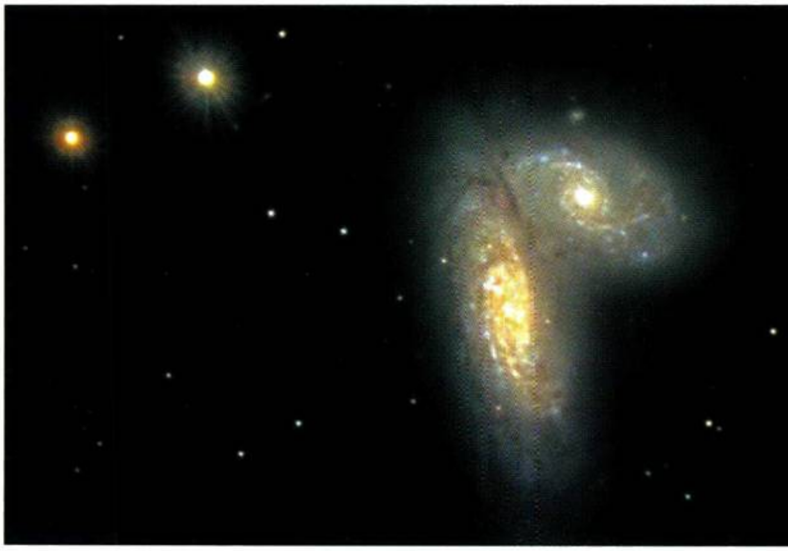
Above. **STAR TRAILS OVER YERKES OBSERVATORY** (Minolta HTSi 35mm camera, Kodak Gold 200 film, tripod-mounted, unguided 15-minute exposure, taken June 28, 2003, 10:45 P.M. CDT, from Williams Bay, Wisconsin) /// **MINA MARIEN**

Right, **THE CONE NEBULA (NGC 2264)** (4-inch Takahashi FSQ106 refractor at f/5.3, SBIG ST-10XME CCD camera, LRGB image of 120, 40, 40, and 60 minutes, respectively, taken February 22, 2003) /// **DANIEL B. PHILLIPS**







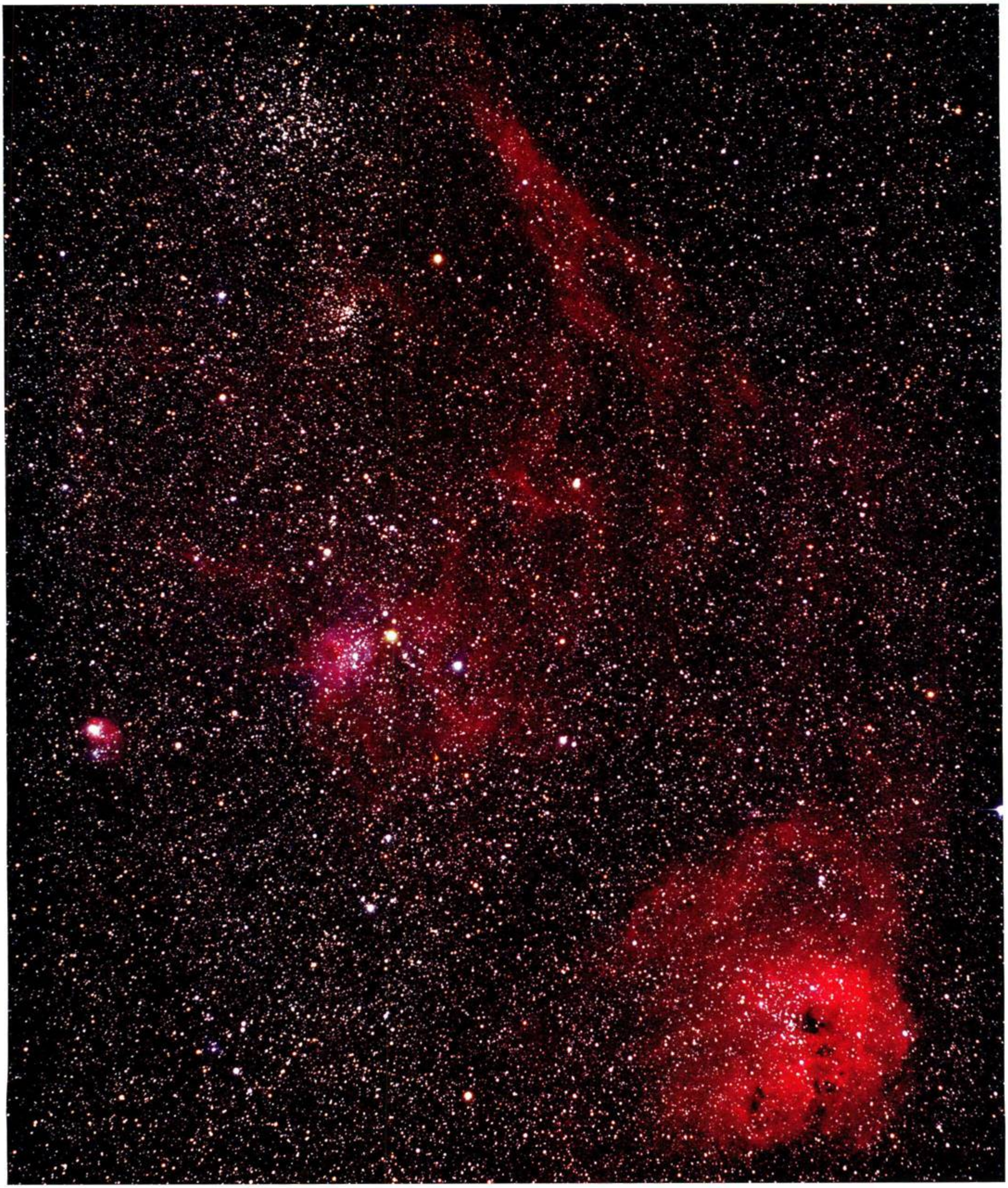


Top left, **MINOR PLANET 346 (HERMENTARIA) CROSSES THE LAGOON NEBULA (M8)** (10-inch Meade Schmidt-Cassegrain telescope at f/6.5, hypered Kodak Technical Pan film, 40-minute exposure, taken July 6, 2003, at 06h43m UT) /// **STEVE SMITH**

Bottom left, **THE VERY OLD (31 HOURS BEFORE NEW) CRESCENT MOON** (3-inch Tele Vue 76 apochromatic refractor at f/5, SBIG ST-10XME CCD camera, 0.11 second exposure, taken 11h30m UT, July 28, 2003, from Kinnear, Wyoming) /// **DEAN SALMAN**

Above, **THE SIAMESE TWINS (NGC 4567 AND NGC 4568) IN VIRGO** (OGS 20-inch Ritchey-Chrétien at f/9, SBIG ST-10XME CCD camera, LRGB image with exposures of 90, 20, 20, and 20 minutes, respectively) /// **BILL AND MARIAN WALLACE AND ADAM BLOCK**

Below. **OPEN CLUSTER M38** [6-inch Astro-Physics EDF refractor at f/7, hypered Kodak PPF Pro 400 film, composite of two 50-minute exposures, taken from Las Vegas, Nevada] /// **GEORGE GREANEY**



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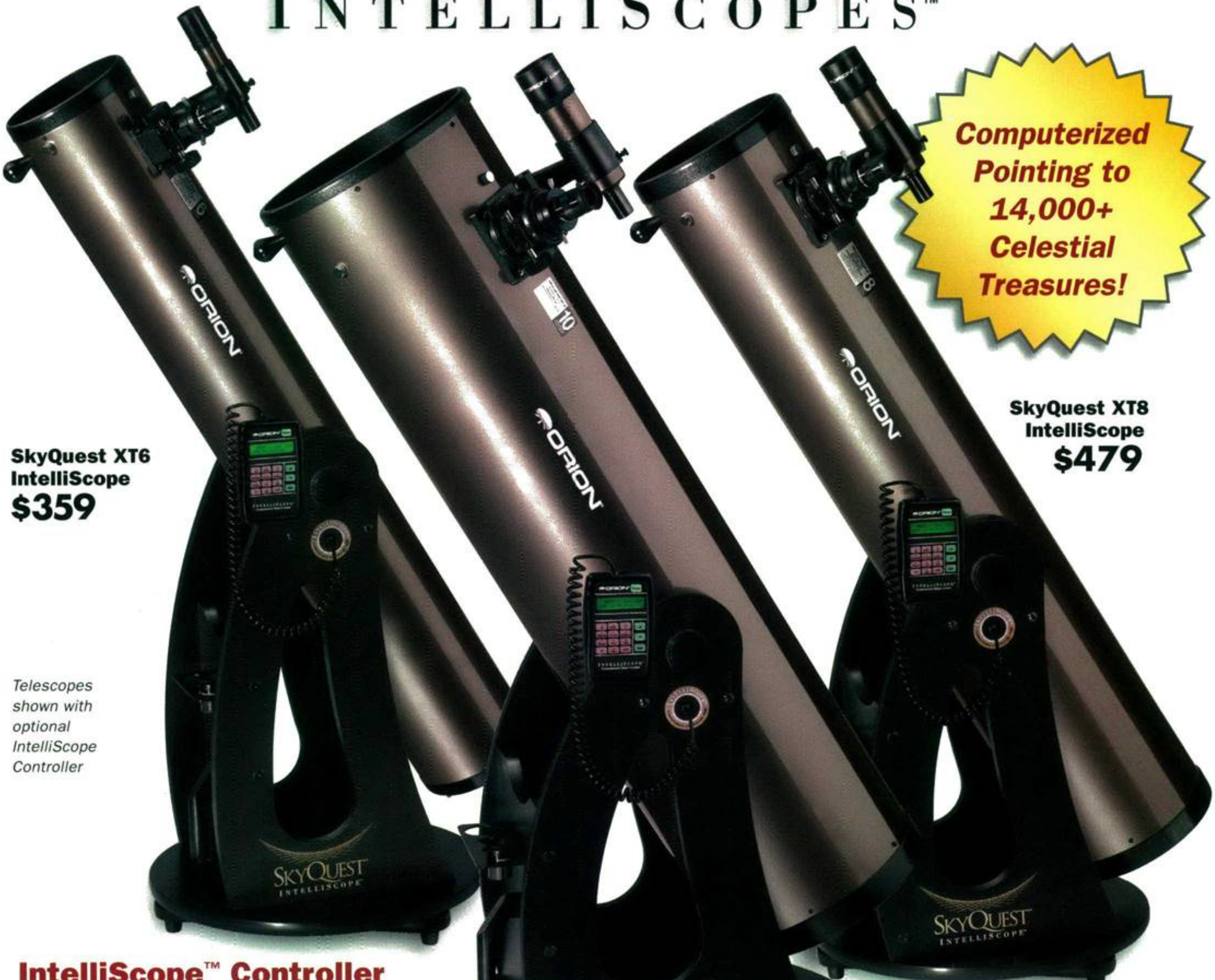

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